NOAA Technical Memorandum NESDIS NGDC-53

DIGITAL ELEVATION MODELS OF JUNEAU AND SOUTHEAST ALASKA: PROCEDURES, DATA SOURCES AND ANALYSIS

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August 2012

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / National Environmental Satellite, Data, and Information Service

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Also available from the National Technical Information Service (NTIS)

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Digital Elevation Models of Juneau and Southeast Alaska: Procedures, Data Sources and Analysis

1. Introduction

In September 2010, the National Geophysical Data Center (NGDC), an office of the National Oceanic and Atmospheric Administration (NOAA), developed three bathymetric–topographic digital elevation models (DEMs) of Southeast Alaska (Fig. 1). The DEMs were developed for the National Tsunami Hazard Mitigation Program (NTHMP; http://nthmp.tsunami.gov/) in support of the State of Alaska's tsunami inundation modeling efforts led by the Geophysical Institute at the University of Alaska at Fairbanks (UAF). The DEMs are nested at 8 arc-second[1], 8/3 arc-second, and 8/15 arc-second, with the highest resolution grid centered on the harbor at Juneau. The coastal DEMs will be used as input for the university-developed modeling system to simulate tsunami generation, propagation, and inundation (http://www.aeic.alaska.edu/tsunami/). The DEMs were generated from diverse digital datasets in the region (grid sources shown in Fig. 7) and were designed to represent modern morphology. This report provides a summary of the data sources and methodology used to develop the Southeast Alaska DEMs.

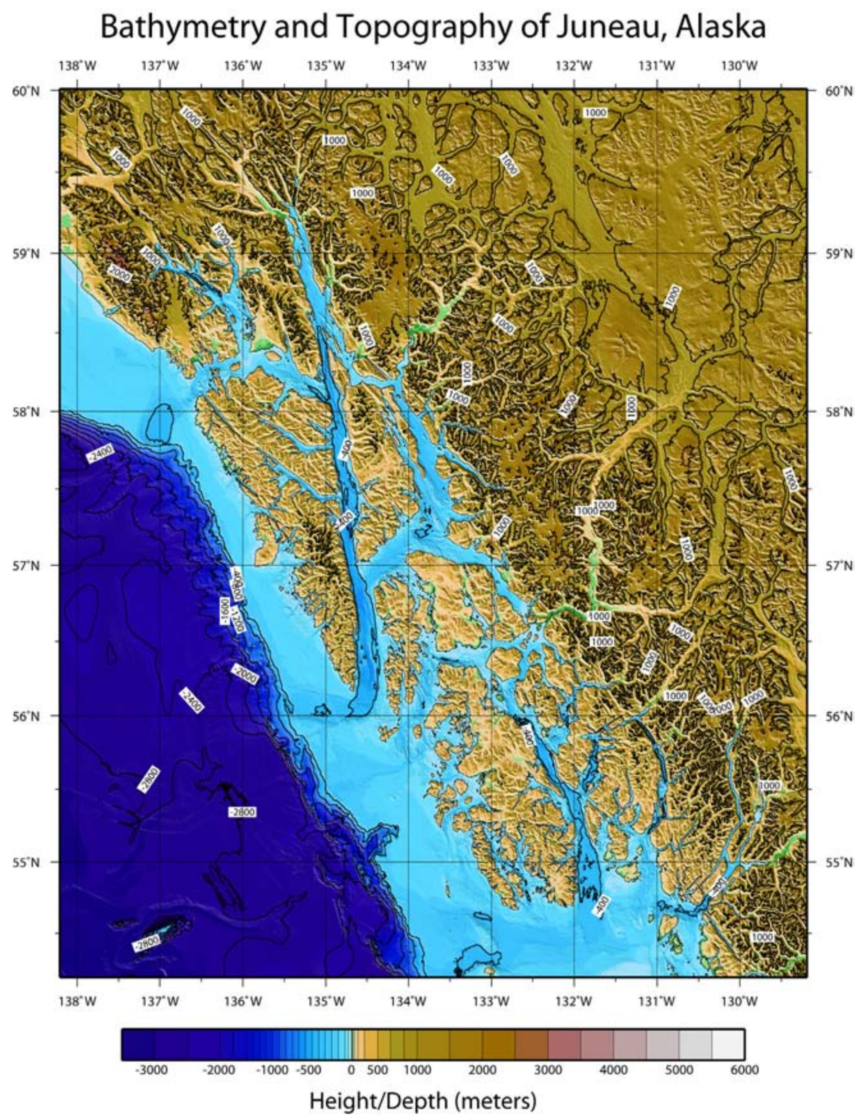

Figure 1. Shaded-relief image of the Southeast Alaska 8 arc-second DEM. Contour interval is 1000 meters on land, 400 meters in water to a depth of 3000 meters, then 1000 meters at depths greater than 3000 meters. Image is in Mercator projection.

1. The Southeast Alaska DEMs are built upon a grid of cells that are square in geographic coordinates (latitude and longitude), however, the cells are not square when converted to projected coordinate systems such as UTM zones (in meters). At the latitude of Juneau, Alaska, (58° 18' 06"N, 134° 25' 11"W) 1 arc-second of latitude is equivalent to 30.94 meters; 1 arc-second of longitude is equivalent to 16.29 meters.

2. Study Area

The City and Borough of Juneau is located on Gastineau Channel in the panhandle of southeastern Alaska. Most of the city lies on the mainland of Alaska, though a portion of the city lies on Douglas Island across the channel. Juneau is situated on a generally flat plain at elevations near sea level with the adjacent mountains of Mount Juneau and Mount Roberts climbing to over 1000 meters (Fig. 2). Two large glaciers lie to the north of the city: the Mendenhall Glacier and the Lemon Creek Glacier. The population according to the U.S. Census Bureau in 2000 was 30,711. The 8 arc-second DEM of the region encompasses the communities of Craig, Elfin Cove, Ketchikan, Port Alexander, Sitka, and Skagway, among others (see Fig. 3).

Southeast Alaska is a historically active earthquake region, which makes the area highly vulnerable to tsunamis (Fig. 4). Earthquakes are of concern in Juneau because of the city's proximity to large fault systems, as well as the likelihood of landslides, avalanches and tsunamis resulting from a significant earthquake. Although most of Alaska's earthquakes occur in the south-central and southwest regions, southeastern Alaska experiences earthquakes from the Queen Charlotte-Fairweather fault, which runs from northwest to southeast in close proximity to the City of Juneau. The Fairweather fault system has caused several recent moderate to large earthquakes: a magnitude 8.1 earthquake in 1949, a magnitude 7.9 event in 1958 that triggered the giant landslide-generated wave, a magnitude 7.6 quake in 1972, and a magnitude 6.8 event in 2004. Because of the steep slopes around Juneau, landslide-induced tsunamis are also possible if an earthquake triggers a large landslide into the channel (http://www.juneau.org/emergency/Earthquakes.php).

Figure 2. Photograph of Juneau and Gastineau Channel from the top of the Mount Roberts Tramway. Source: http://www.flickr.com/photos/samglover/. Uploaded July 15, 2008 by author Sam Glover, Minneapolis, Minnesota.

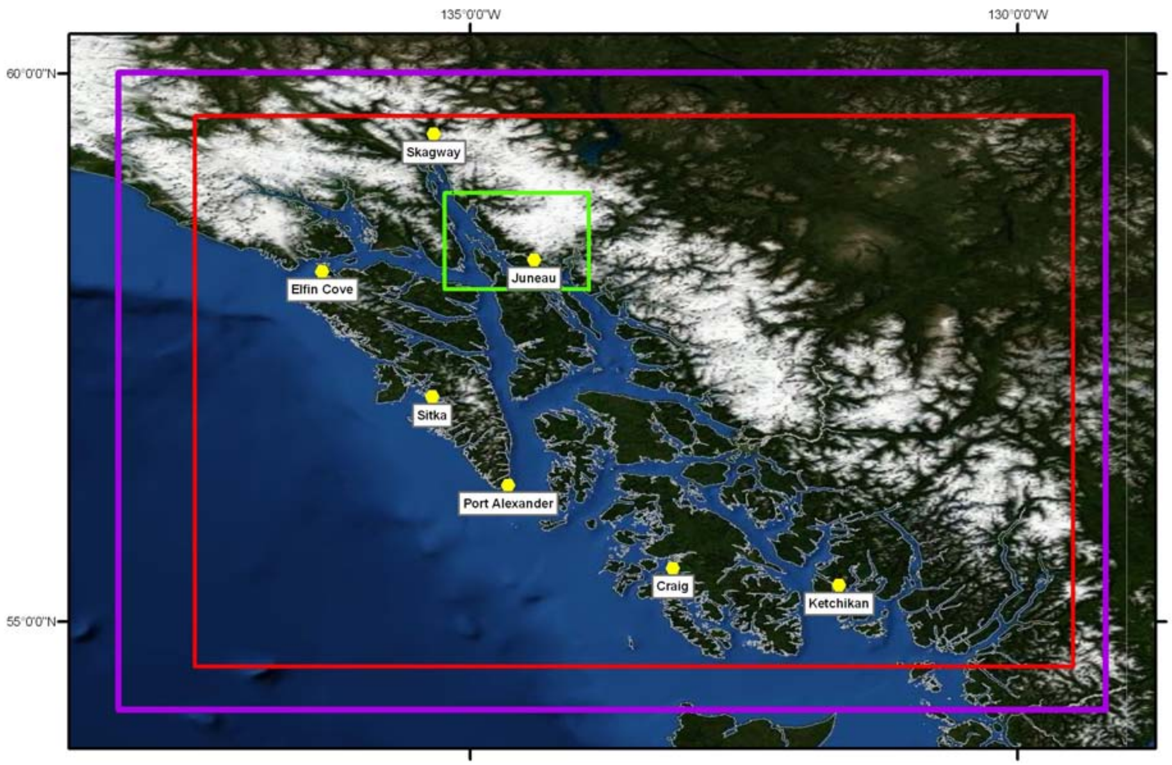

Figure 3. *Overview of the Southeast Alaska region. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are shown. Locations of several cities and towns are also displayed. ESRI World 2D imagery is in the background.*

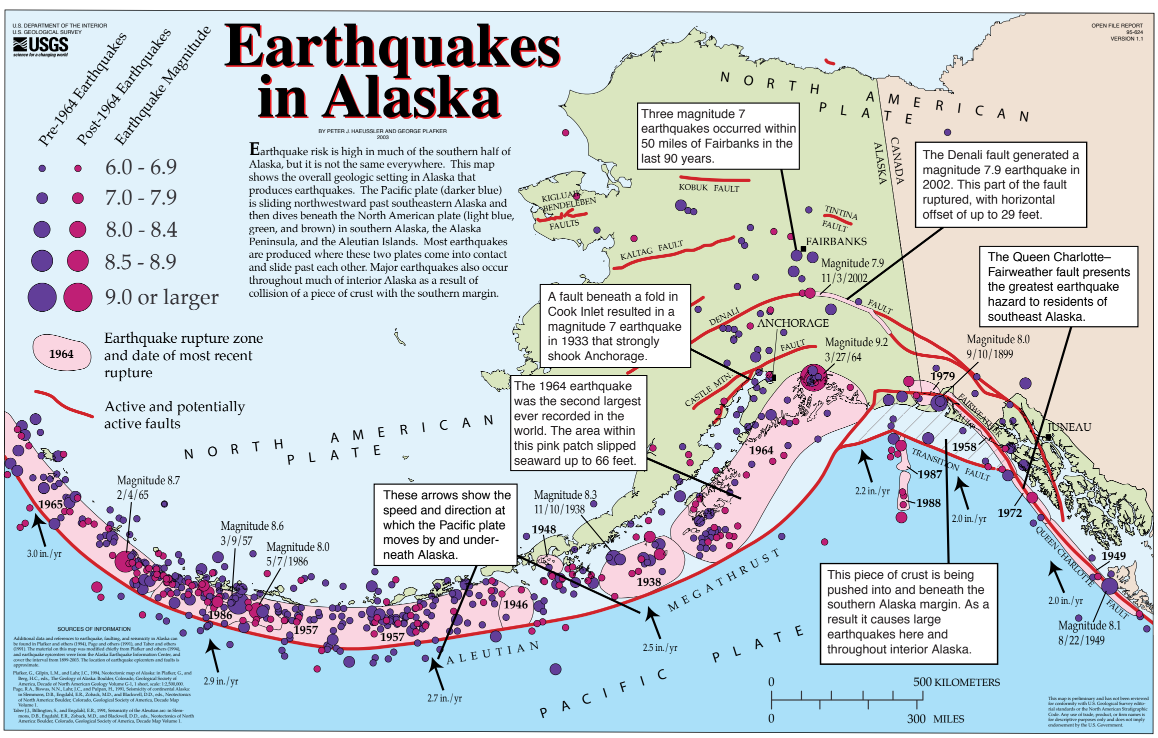

Figure 4. *Earthquakes in Alaska. Sources: http://www.aeic.alaska.edu/html_docs/pdf_files/earthquakes_in_Alaska.pg.pdf; http://geopubs.wr.usgs.gov/open-file/of95-624/.*

3. Methodology

The Southeast Alaska DEMs were developed in the World Geodetic System 1984 (WGS 84) geographic horizontal datum and Mean Higher High Water (MHHW) vertical datum in vertical units of meters. The final grid format for each of the DEMs is netCDF. The Southeast Alaska DEMs were also developed to meet the specifications listed in Table 1. The best available bathymetric and topographic digital data were obtained by NGDC and shifted to common horizontal and vertical datums: North American Datum of 1983[2] (NAD 83) and MHHW, for modeling of maximum flooding, respectively.

Table 1. Specifications for the Southeast Alaska DEMs.

Grid Area	Southeast Alaska		Juneau
Coverage Area	138.21º to 129.19º W; 54.19º to 60.01º N	137.51º to 129.49º W; 54.59º to 59.61º N	135.23º to 133.91º W; 58.03º to 58.91º N
Grid Spacing	8 arc-seconds	8/3 arc-second	8/15 arc-second
Coordinate System	Geographic decimal degrees		
Horizontal Datum	World Geodetic System 1984 (WGS 84)		
Vertical Datum	Mean Higher High Water (MHHW)		
Vertical Units	Meters		
Grid Format	netCDF		

NGDC developed the DEMs at extents larger than currently required by UAF (Fig. 5). As part of NTHMP, UAF will require additional DEMs in Southeast Alaska (Fig. 6). By developing the 8 and 8/3 arc-second DEMs at a larger spatial extent, subsequent 8/15 arc-second DEMs within the region should only require the collection of newer or updated bathymetric and topographic datasets.

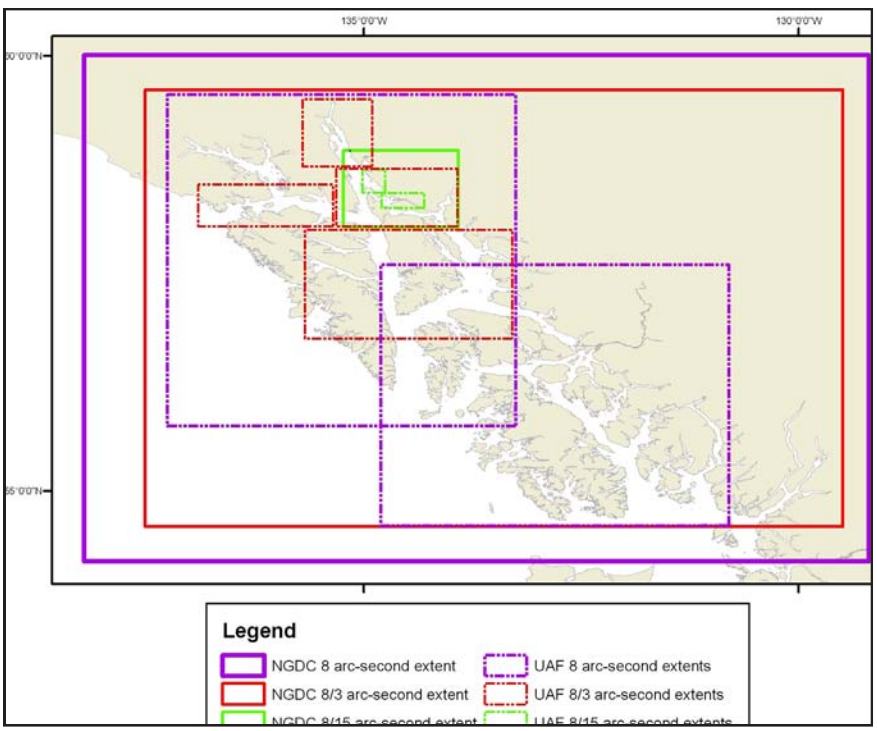

Figure 5. Comparison of NGDC and UAF DEM extents in the Southeast Alaska region. Coastline shown in grey; land areas in tan.

2. The horizontal difference between the North American Datum of 1983 (NAD 83) and World Geodetic System of 1984 (WGS 84) geographic horizontal datums is approximately one meter across the contiguous U.S., which is significantly less than the cell size of the DEMs. Most GIS applications treat the two datums as identical, so do not actually transform data between them, and the error introduced by not converting between the datums is insignificant for our purposes. NAD 83 is restricted to North America, while WGS 84 is a global datum. As tsunamis may originate most anywhere around the world, tsunami modelers require a global datum, such as WGS 84 geographic, for their DEMs so that they can model the wave's passage across ocean basins. These DEMs are identified as having a WGS 84 geographic horizontal datum even though the underlying elevation data were typically transformed to NAD 83 geographic. At the scale of the DEMs, WGS 84 and NAD 83 geographic are identical and may be used interchangeably.

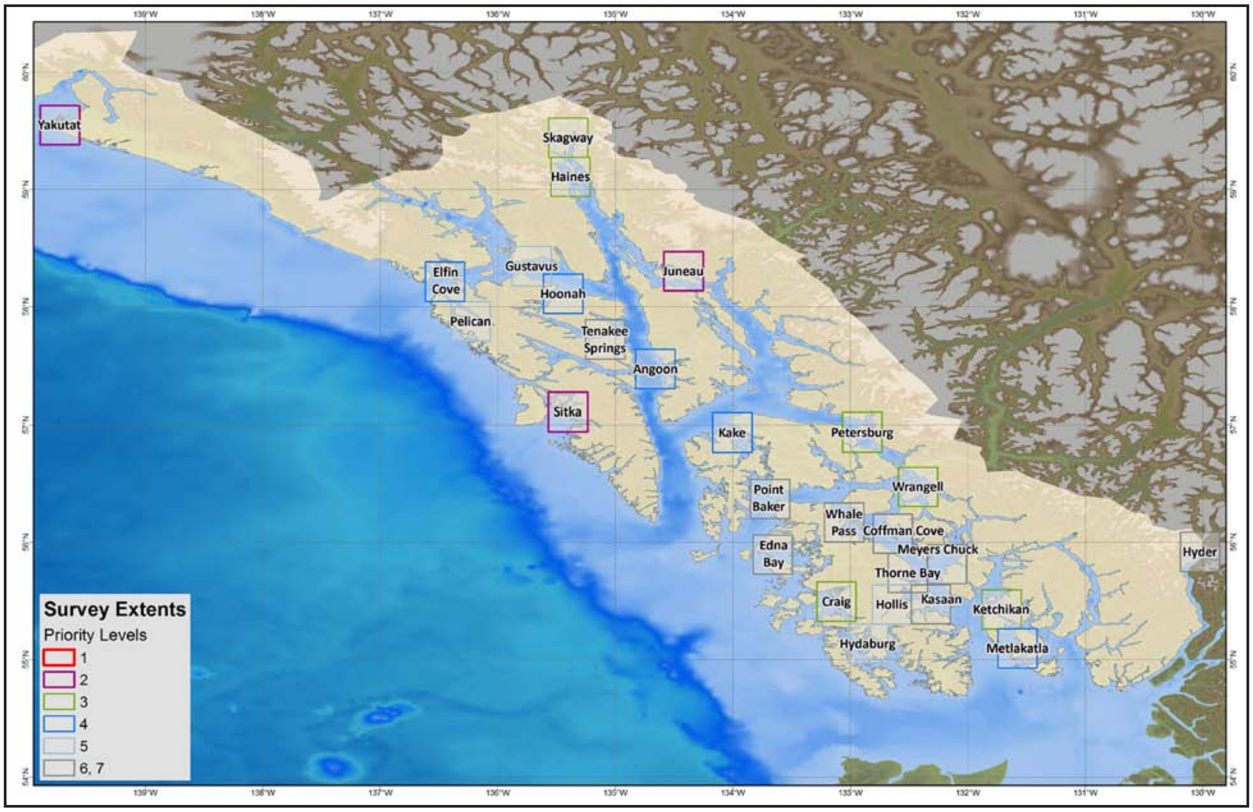

Figure 6. Planned NTHMP DEMs in Southeast Alaska. Priority levels are unofficial. Yakutat DEM completed in 2009. Graphic courtesy of UAF.

1.1 Data Sources and Processing

Shoreline, bathymetric, and topographic digital datasets (Fig. 7) were obtained from several U.S. federal and local agencies, and Canada, including: NGDC; NOAA's National Ocean Service (NOS), Office of Coast Survey (OCS); the U.S. Fish and Wildlife Service (USFWS); the U.S. Forestry Service (USFS); the U.S. Army Corps of Engineers (USACE); the U.S. Geological Survey (USGS); the National Aeronautics and Space Administration (NASA); the Canadian Hydrographic Service (CHS); and the City of Juneau. Safe Software's *Feature Manipulation Engine* (*FME*)[3] data translation tool package and *Proj4*[4] were used to shift datasets to NAD 83 geographic horizontal datum. *FME*, *GDAL*[5], and *OGR*[6] were used to convert the datasets into ESRI *ArcGIS* shapefiles and xyz format. The shapefiles and xyz files were then displayed with *ArcGIS* and Applied Imagery's *Quick Terrain Modeler* (*QT Modeler*) to assess data quality and manually edit datasets. The methodology used for vertical datum transformations is described in Section 3.2.1. *QT Modeler* and Interactive Visualization System's *Fledermaus* software were used to evaluate processing and gridding techniques.

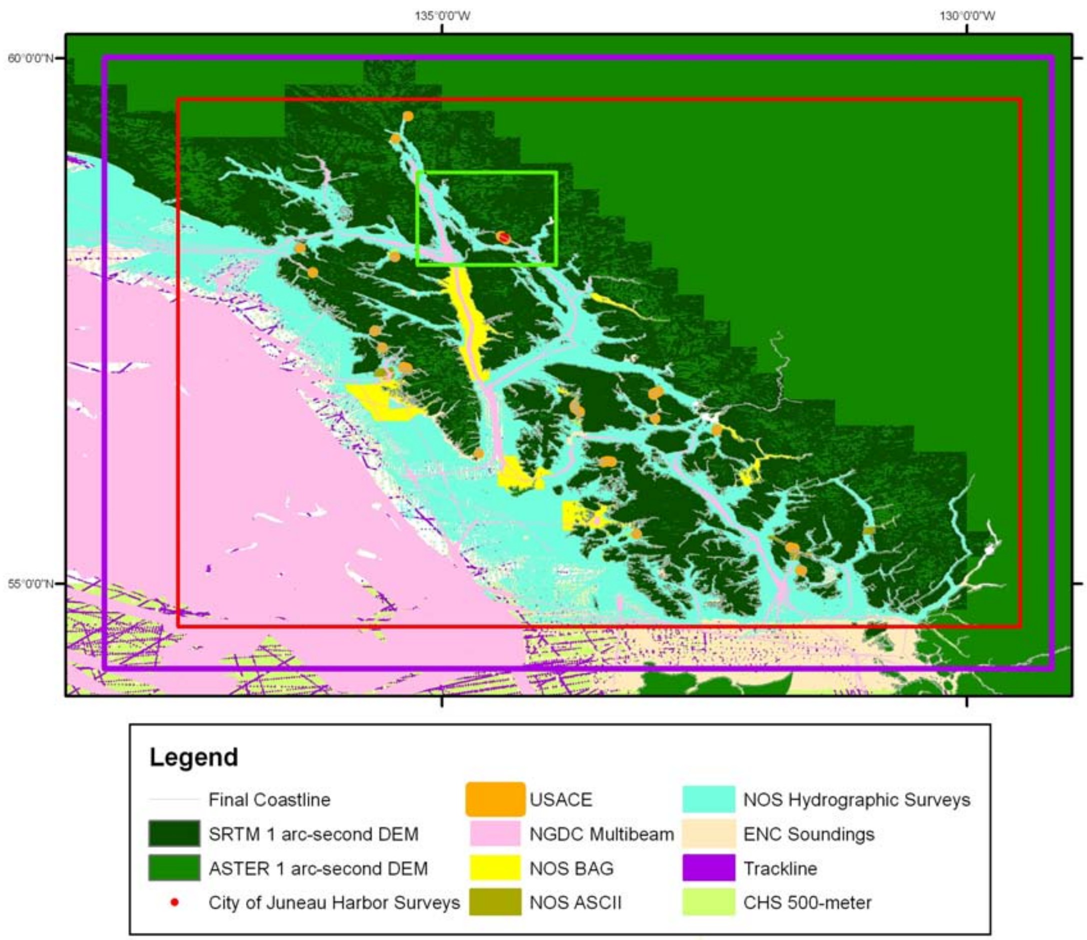

Figure 7. Source and coverage of datasets used in compiling the Southeast Alaska DEMs. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are shown.

3. *FME* uses the North American Datum Conversion Utility (NADCON; http://www.ngs.noaa.gov/TOOLS/Nadcon/Nadcon.shtml) developed by NOAA's National Geodetic Survey (NGS) to convert data from NAD 27 to NAD 83. NADCON is the U.S. Federal Standard for NAD 27 to NAD 83 datum transformations.
4. *Proj4* is a cartographic projections library, originally written by Gerald Evenden, then of the USGS. The software is released under an MIT style Open Source license. *Proj4* was used to horizontally transform datasets that originated in State Plane datums before vertical transformations were performed .
5. *GDAL* is a translator library for raster geospatial data formats that is released under an X/MIT style Open Source license by the Open Source Geospatial Foundation. As a library, it presents a single abstract data model to the calling application for all supported formats. It also comes with a variety of useful command-line utilities for data translation and processing.
6. The *OGR* Simple Features Library is a C++ open source library and command-line tools providing read and write access to a variety of vector file formats, including ESRI shapefiles. *OGR* is a part of the *GDAL* library.

1.1.1 Shoreline

Two coastline datasets of the Southeast Alaska region were analyzed for inclusion in the Southeast Alaska DEMs: NOAA Electronic Navigational Charts (ENCs)[7] and the USFWS statewide Alaska digital coastline (Table 2; Fig. 8). The USFWS coastline best fit the topographic and bathymetric data overall and was merged with higher resolution (e.g., at least 1:80,000 scale) ENC coastlines only within the 8/15 arc-second extents to improve representation of the coastline in the immediate vicinity of the City of Juneau (Fig. 9). These datasets were used to develop a "final coastline" of the Southeast Alaska region (see Fig. 7).

The final coastline was subsequently modified to include large offshore rocks and small islets shown on the larger-scale NOAA raster nautical charts (RNCs) and clipped to 0.05 degrees larger than the 8 arc-second DEM boundary. Piers and docks were deleted from the coastline. The coastline was further modified based on *ESRI World 2D* imagery to reflect the most current coastal morphology, particularly within the 8/15 arc-second extents.

Table 2. Shoreline datasets used in developing the Southeast Alaska DEMs.

Source	*Year*	*Data Type*	*Spatial Resolution*	*Original Horizontal Datum/ Coordinate System*	*Original Vertical Datum*	*URL*
OCS	2009	ENC	1:20,000 to 1:80,000	WGS 84 geographic	MHW	http://www.nauticalcharts.noaa.gov/mcd/enc/index.htm
USFWS	2006	Compiled coastline	1:63,360	WGS 84 geographic	Undefined	ftp://ftp.dnr.state.ak.us/asgdc/adnr/alaska_63360.zip

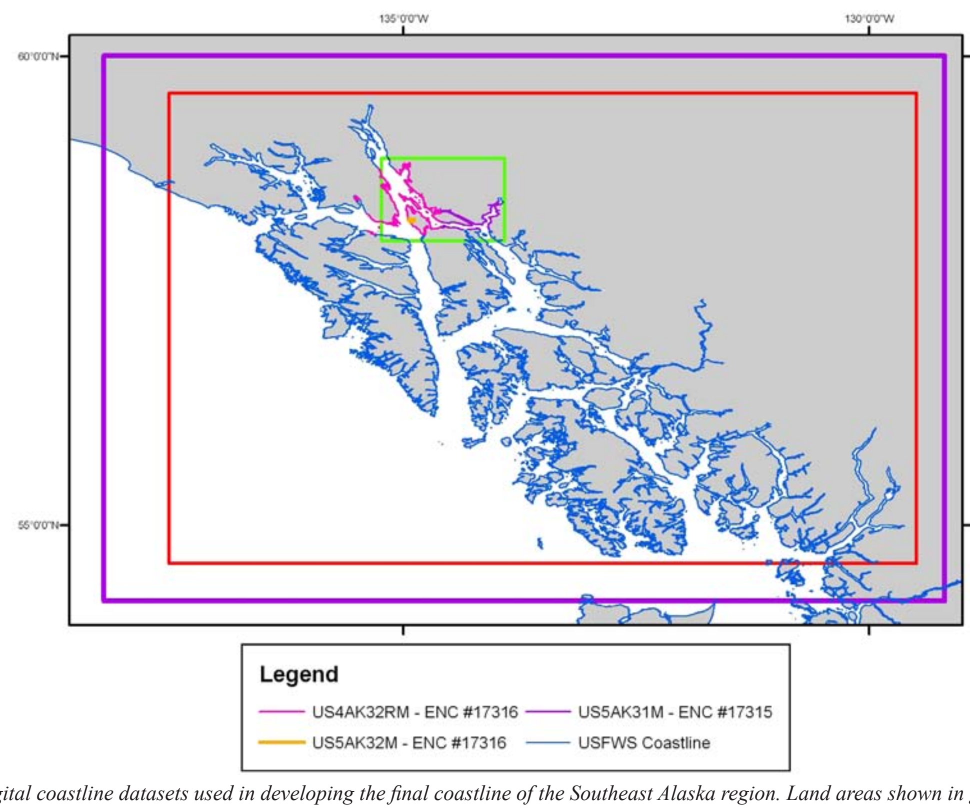

Figure 8. Digital coastline datasets used in developing the final coastline of the Southeast Alaska region. Land areas shown in gray. Water areas shown in white. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are also shown.

7. The Office of Coast Survey (OCS) produces NOAA Electronic Navigational Charts (NOAA ENC®) to support the marine transportation infrastructure and coastal management. NOAA ENCs® are in the International Hydrographic Office (IHO) S-57 international exchange format, comply with the IHO ENC Product Specification and are provided with incremental updates, which supply Notice to Mariners corrections and other critical changes. NOAA ENCs® are available for free download on the OCS web site. [Extracted from NOAA OCS web site: http://www.nauticalcharts.noaa.gov/mcd/enc/index.htm]

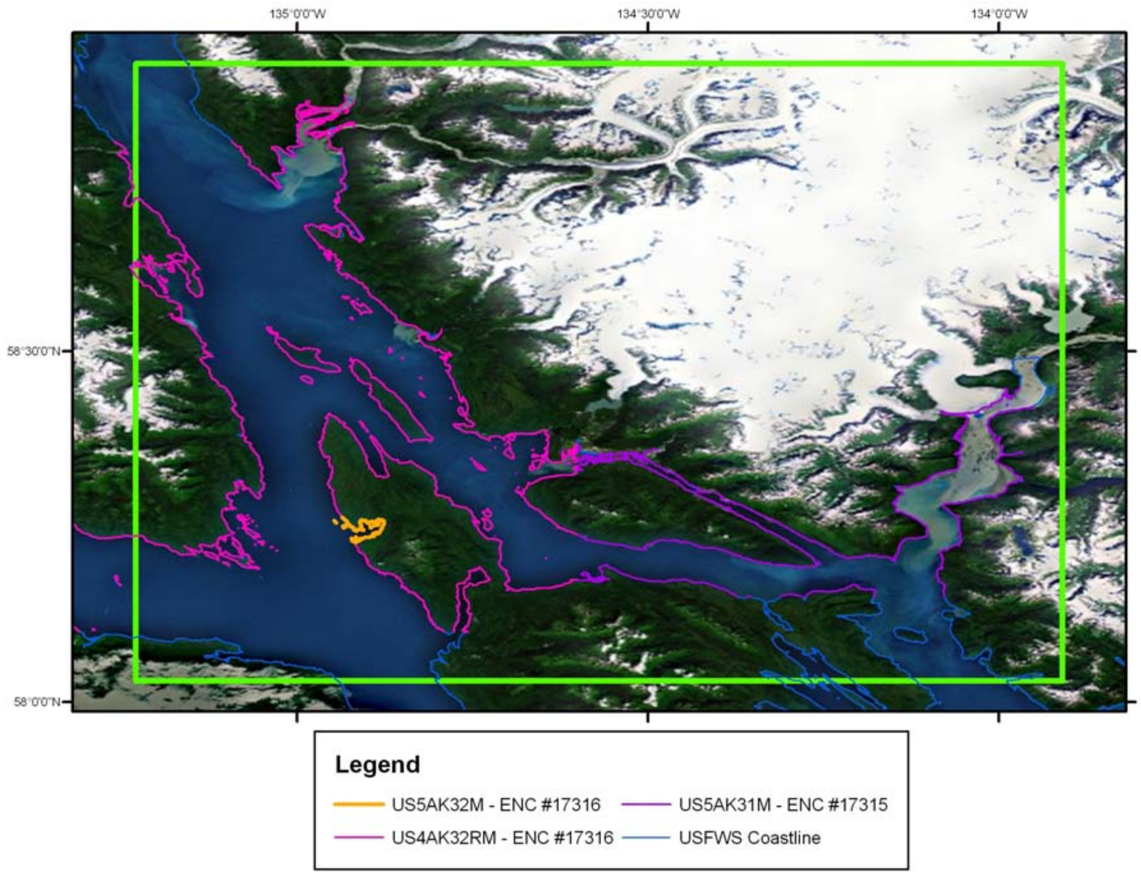

Figure 9. Coastlines available in the vicinity of Juneau. Extent of the 8/15 arc-second DEM in green. ESRI World 2D imagery shown in the background.

1) Office of Coast Survey extracted Electronic Navigational Chart coastlines

Thirty-seven ENCs were available in the Southeast Alaska region (Appendix A) and were downloaded from NOAA's Office of Coast Survey web site. The ENCs were in S-57 format and included coastline data referenced to MHW. The coastline shapefiles were extracted from the ENCs using *ArcCatalog* and compared to large-scale RNCs and ESRI's *World 2D* imagery. Only the ENCs with 1:80,000 scale or higher that were within the 8/15 arc-second DEM boundary were used (Fig. 9). These two ENCs, #17315 and #17316, provided improved representation in the region immediately surrounding the City of Juneau, including portions of the Gastineau Channel and Douglas Island.

2) U.S. Fish and Wildlife Service vector coastline

The U.S. Fish and Wildlife Service (USFWS) has compiled a seamless digital coastline of the State of Alaska from a variety of sources, including: the National Hydrography Dataset, NOAA nautical charts, USFWS, National Geographic Topo Software, USACE, and Alaska Department of Natural Resources. This dataset was graciously provided by Bret Christensen, USFWS. Though efforts were made to obtain the highest resolution coastlines available, vertical datums were not determined or controlled in the compilation of the USFWS coastline; the horizontal datum is WGS 84 geographic. The USFWS coastline provides complete coverage of the Southeast Alaska region.

1.1.2 Bathymetry

Bathymetric datasets available for use in the compilation of the Southeast Alaska DEMs include 749 NOS hydrographic surveys; 19 multibeam surveys downloaded from the NGDC multibeam database; 26 hydrographic surveys from USACE; 53 NGDC trackline surveys; 2 harbor surveys from the City and Borough of Juneau; a gridded bathymetric dataset from the Canadian Hydrographic Service; and soundings extracted from ENCs. (Table 3; Fig. 10).

Table 3. Bathymetric datasets used in compiling the Southeast Alaska DEMs.

Source	*Year*	*Data Type*	*Spatial Resolution*	*Downloaded Horizontal Datum/ Coordinate System*	*Original Vertical Datum*	*URL*
NGDC	1883 to 2009	NOS hydrographic surveys	Ranges from less than 10 m to 600 m (varies with scale of survey, depth, traffic, and probability of obstructions)	NAD 83 geographic	MLW and MLLW	http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html
NGDC	1994 to 2009	Multibeam swath sonar	Gridded to 3 arc-seconds	WGS 84 geographic	Assumed Mean Sea Level (MSL)	http://www.ngdc.noaa.gov/mgg/bathymetry/multibeam.html
USACE	1999 to 2008	Hydrographic surveys	Ranges from less than 10 m to over 100 meters (varies with scale of survey, depth, traffic, and probability of obstructions)	NAD 83 Alaska State Plane Zone I (US survey feet)	MLLW (feet)	http://www.poa.usace.army.mil/en/hydro/
NGDC	1959 to 1999	Trackline surveys	Ranges from several meters to several kilometers (varies with scale of survey, depth, traffic, and probability of obstructions)	WGS 84 geographic	Assumed MSL	http://www.ngdc.noaa.gov/mgg/geodas/trackline.html
City of Juneau	2010	Harbor survey	Ranges from several meters to several tens of meters	NAD 83 Alaska State Plane Zone I (US survey feet)	MLLW (feet)	http://www.juneau.lib.ak.us/harbors/
CHS	2001 and 2010	Gridded bathymetry point data	~ 500 meters	NAD 83 Albers Conical Equal Area - British Columbia	Assumed MSL	http://chs-shc.gc.ca/
OCS	1977 to 2009	ENC extracted soundings	Ranges from several meters to several kilometers (varies with scale of survey, depth, traffic, and probability of obstructions)	WGS 84 geographic	MLLW	http://w1.nauticalcharts.noaa.gov/staff/chartspubs.html

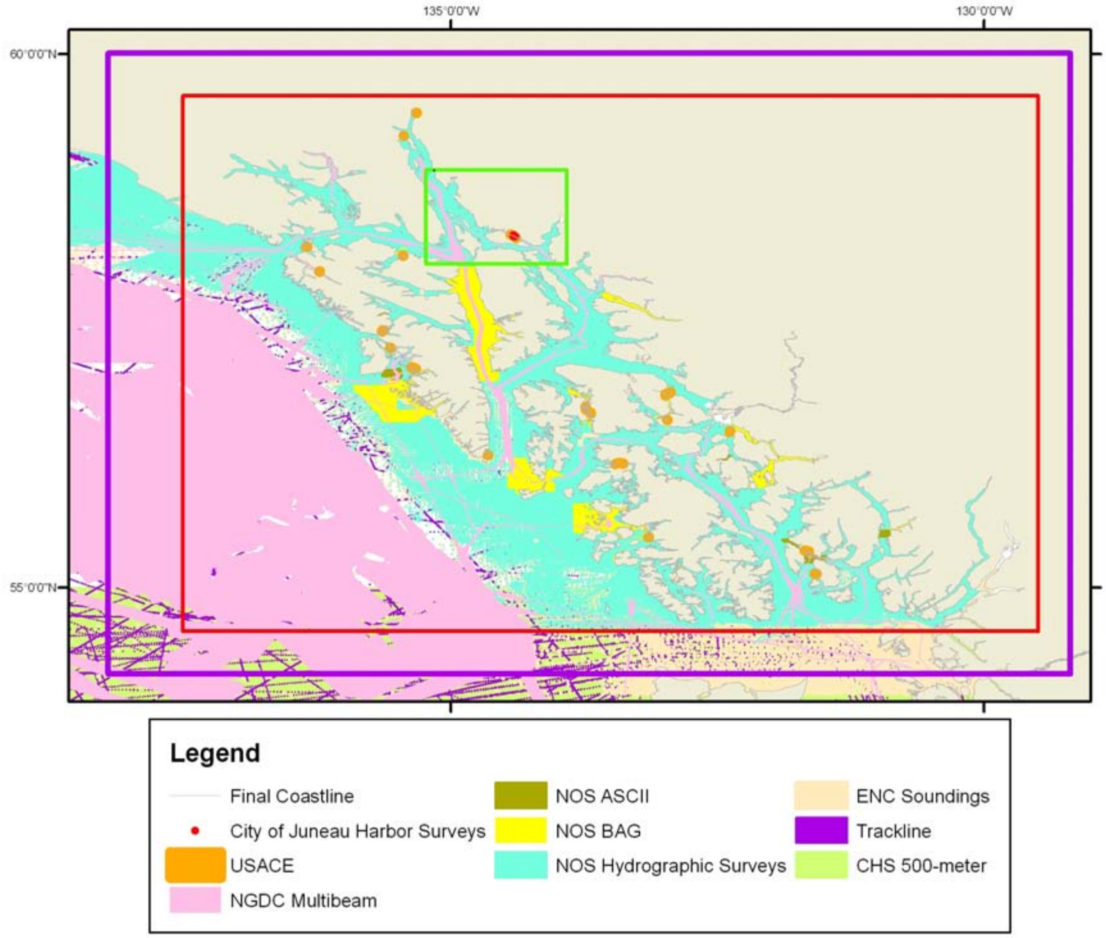

Figure 10. Spatial coverage of the bathymetric datasets used in compiling the Southeast Alaska DEMs. Land areas shown in tan. Regions of no data shown in white. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are also shown.

1) National Ocean Service hydrographic survey data

A total of 749 NOS hydrographic surveys conducted between 1883 and 2009 were available for use in developing the Southeast Alaska DEMs (Appendix B; Figs. 11 and 12). Surveys were extracted from NGDC's online NOS hydrographic database using *GEODAS*[8]. The surveys were downloaded in xyz (656 surveys), ASCII grid (9 surveys), or bathymetric attributed grid (BAG; 84 surveys) format. The downloaded hydrographic survey data were vertically referenced to mean lower low water (MLLW) or mean low water (MLW) and horizontally referenced to NAD 27 or NAD 83 geographic, NAD 83 UTM Zone 8, NAD 83 UTM Zone 9, Early Alaska, or "undetermined" datums. NOS surveys in Early Alaska or "undetermined" datums were manually shifted in *ArcGIS* to fit the final coastline.

Data point spacing for the NOS surveys varied by scale. In general, small scale surveys had greater point spacing than large scale surveys. The data were converted to shapefiles using *Python* scripting and *GDAL*. The surveys were subsequently clipped to a polygon 0.05 degree (~5%) larger than the Southeast Alaska DEM area to support data interpolation along grid edges.

After converting all NOS survey data to MHHW (see Sec. 3.2.1), the data were displayed in ESRI *ArcMap* and reviewed for digitizing errors against scanned original survey smooth sheets and edited as necessary. The surveys were also compared to other bathymetric datasets, the final coastline, and NOS RNCs (see Appendix A). Older surveys were clipped to remove soundings that have been superseded by more recent NOS surveys, USACE surveys, and multibeam data.

8. *GEODAS* uses the North American Datum Conversion Utility (NADCON; http://www.ngs.noaa.gov/TOOLS/Nadcon/Nadcon.shtml) developed by NOAA's National Geodetic Survey (NGS) to convert hydrographic survey data from NAD 27 to NAD 83. NADCON is the U.S. Federal Standard for NAD 27 to NAD 83 datum transformations.

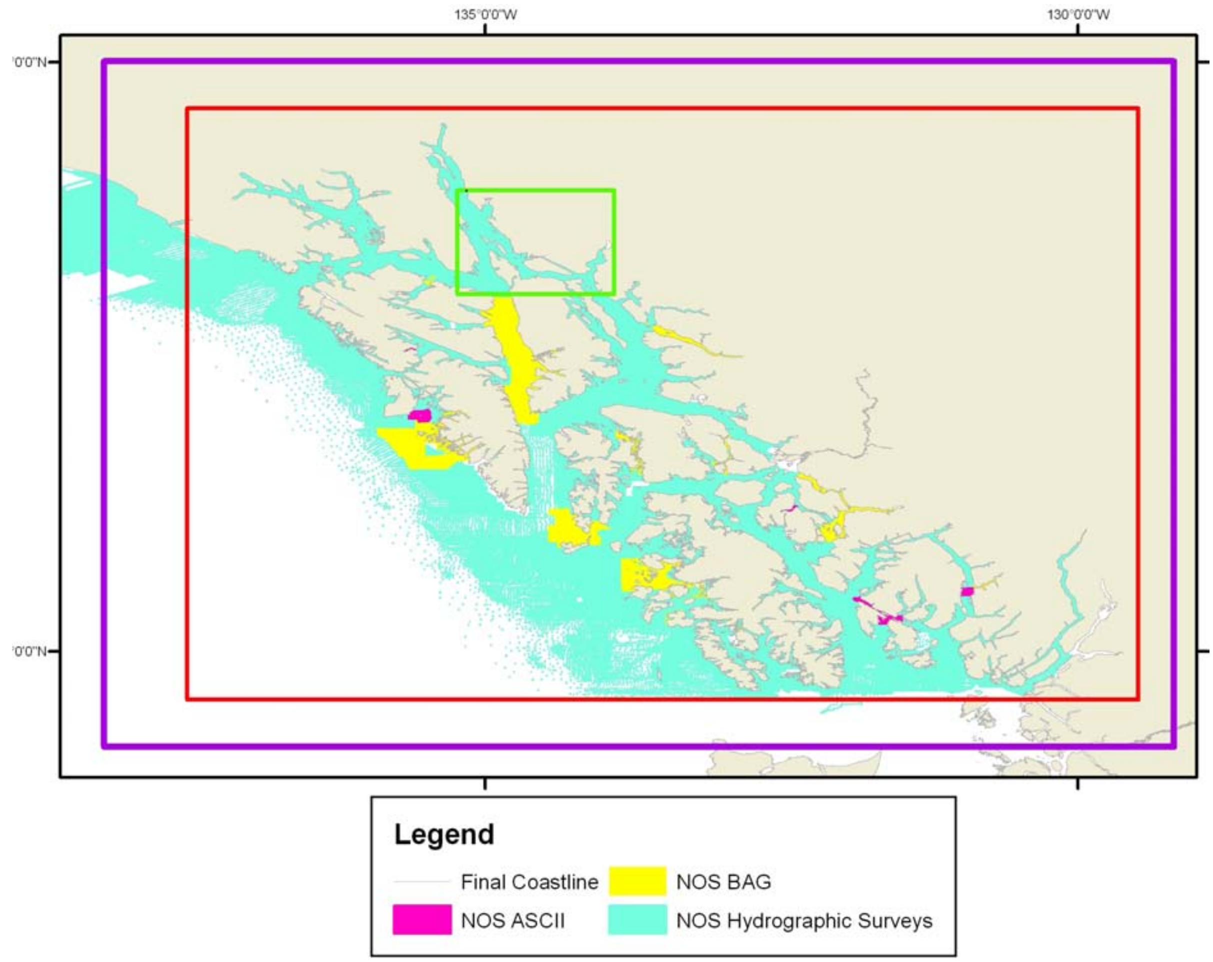

Figure 11. Digital NOS hydrographic survey coverage in the Southeast Alaska region. Several older surveys were not used as they have been superseded by more recent surveys. Land areas shown in tan. Regions where NOS data were not available are shown in white. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are also shown.

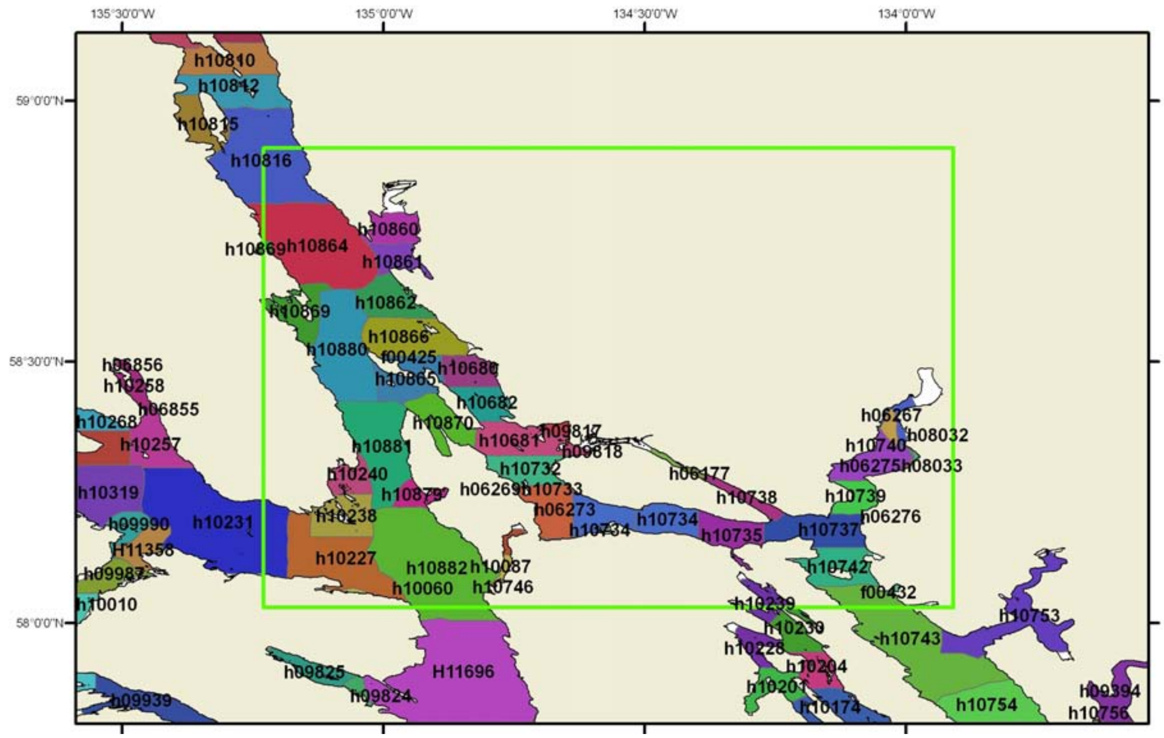

Figure 12. Digital NOS hydrographic survey coverage in the vicinity of Juneau. Several older surveys were not used as they have been superseded by more recent surveys. Land areas shown in tan. Regions where NOS data were not available are shown in white. Extent of the 8/15 arc-second (green) DEM is also shown.

2) NGDC multibeam swath sonar surveys

Nineteen multibeam swath sonar surveys were available from the NGDC multibeam bathymetry database for use in building the Southeast Alaska DEMs (Table 4; see Fig. 7). The data were referenced to WGS 84 geographic horizontal datum and were assumed to be referenced to MSL vertical datum. The data were gridded at 3 arc-seconds at extents approximately 5 percent (~0.10 degree) larger than the 8 arc-second DEM extents using *MB-System*[9] (http://www.ldeo.columbia.edu/res/pi/MB-System/). The grids were converted to xyz format and viewed in *QT Modeler* for quality analysis. Multibeam survey KM0514 contained inconsistencies along the swath edges in deep water (> 2000 meters); therefore, this survey was gridded at 24 arc-seconds to smooth the surface and provide data in a region of limited data availability. Editing was done using *QT Modeler* and *ArcMap* to eliminate errors where survey data overlapped. The elevations were then transformed from MSL to MHHW (see Sec. 3.2.1) for use in the final gridding process.

9. *MB-System* is an open source software package for the processing and display of bathymetry and backscatter imagery data derived from multibeam, interferometry, and sidescan sonars. The source code for *MB-System* is freely available (for free) by anonymous ftp (including "point and click" access through these web pages). A complete description is provided in web pages accessed through the web site. *MB-System* was originally developed at the Lamont-Doherty Earth Observatory of Columbia University (LDEO) and is now a collaborative effort between the Monterey Bay Aquarium Research Institute (MBARI) and LDEO. The National Science Foundation has provided the primary support for *MB-System* development since 1993. The Packard Foundation has provided significant support through MBARI since 1998. Additional support has derived from SeaBeam Instruments (1994-1997), NOAA (2002-2004), and others. URL: http://www.ldeo.columbia.edu/res/pi/MB-System/ [Extracted from *MB-System* web site.]

Table 4. NGDC multibeam swath sonar surveys used in compiling the Southeast Alaska DEMs.

Survey ID	*Year*	*Collecting Institution*	*Ship*
AT03L37	1999	Woods Hole Oceanographic Institution (WHOI)	Atlantis
AT11L15	2004	WHOI	Atlantis
EW0408	2004	Columbia University, Lamont-Doherty Earth Observatory (LDEO)	Maurice Ewing
EW9413	1994	LDEO	Maurice Ewing
HLY04TG*	2004	United States Coast Guard (USCG)	USCGC Healy
HLY04TH*	2004	USCG	USCGC Healy
HLY06TI	2006	USCG	USCGC Healy
HLY06TJ	2006	USCG	USCGC Healy
HLY07TH	2007	USCG	USCGC Healy
HLY07TI	2007	USCG	USCGC Healy
HLY08TC	2008	USCG	USCGC Healy
HLY08TD	2008	USCG	USCGC Healy
HLY08TG	2008	USCG	USCGC Healy
HLY08TI	2008	USCG	USCGC Healy
HLY09TB	2009	USCG	USCGC Healy
HLY09TC	2009	USCG	USCGC Healy
HLY09TD	2009	USCG	USCGC Healy
HLY09TE	2009	USCG	USCGC Healy
KM0514	2005	LDEO	Kilo Moana
LWAD99MV	1999	SIO	Melville
NBP0206A	2002	LDEO	Nathaniel B. Palmer
NPAL98MV	1998	SIO	Melville
NV9704MV	1997	SIO	Melville
OXMZ01MV	1999	SIO	Melville
REVT01RR	1996	SIO	Roger Revelle
WEST15MV	1995	SIO	Melville

** indicates data were not used due to poor quality or overlapped by more recent survey*

3) U.S. Army Corps of Engineers hydrographic surveys

Forty-two channel line survey datasets in xyz format were downloaded from the USACE Alaska District web site (Table 5; Fig. 13). The surveys were horizontally referenced to NAD 83 Alaska State Plane Zone I (U.S. survey feet) and vertically referenced to MLLW (U.S. survey feet). Each survey was transformed to NAD 83 geographic using *Proj4* and transformed to MHHW using the method described in Section 3.2.1. Older surveys were clipped to remove soundings that have been superseded by more recent NOS, multibeam, or USACE surveys (e.g., Fig. 14).

Table 5. USACE hydrographic surveys used in compiling the Southeast Alaska DEMs.

Survey Name	Year
Aurora Harbor	2002, 2005
Craig South Cove Harbor	2003, 2007
Douglas	2000, 2003
Dry Pass	2005
Elfin Cove Navigation Channel	2003, 2007
Haines Harbor	2000, 2008
Harris Harbor	2002, 2005
Hoonah	2002
Kake Harbor *	2000
Ketchikan	2001, 2007
Metlakatla	2007
Mountain Point *	1998
Metlakatla New Harbor	2003
Metlakatla Old Harbor *	2003
Pelican	2003, 2007
Petersburg North Harbor	2003, 2008
Port Alexander	1999, 2005
Rocky Pass	2001, 2007
Sergius Whitestone	2001, 2005
Sitka Channel Rock Breakwaters	2001, 2005, 2008
Sitka Crescent Bay Harbor	2005
Sitka Western Channel	2001
Skagway	2000, 2008
Wrangell Harbor	2007
Wrangell Narrows	2003, 2008
Wrangell *	2001

** indicates no xyz file available - only graphical depictions of survey region were downloaded.*

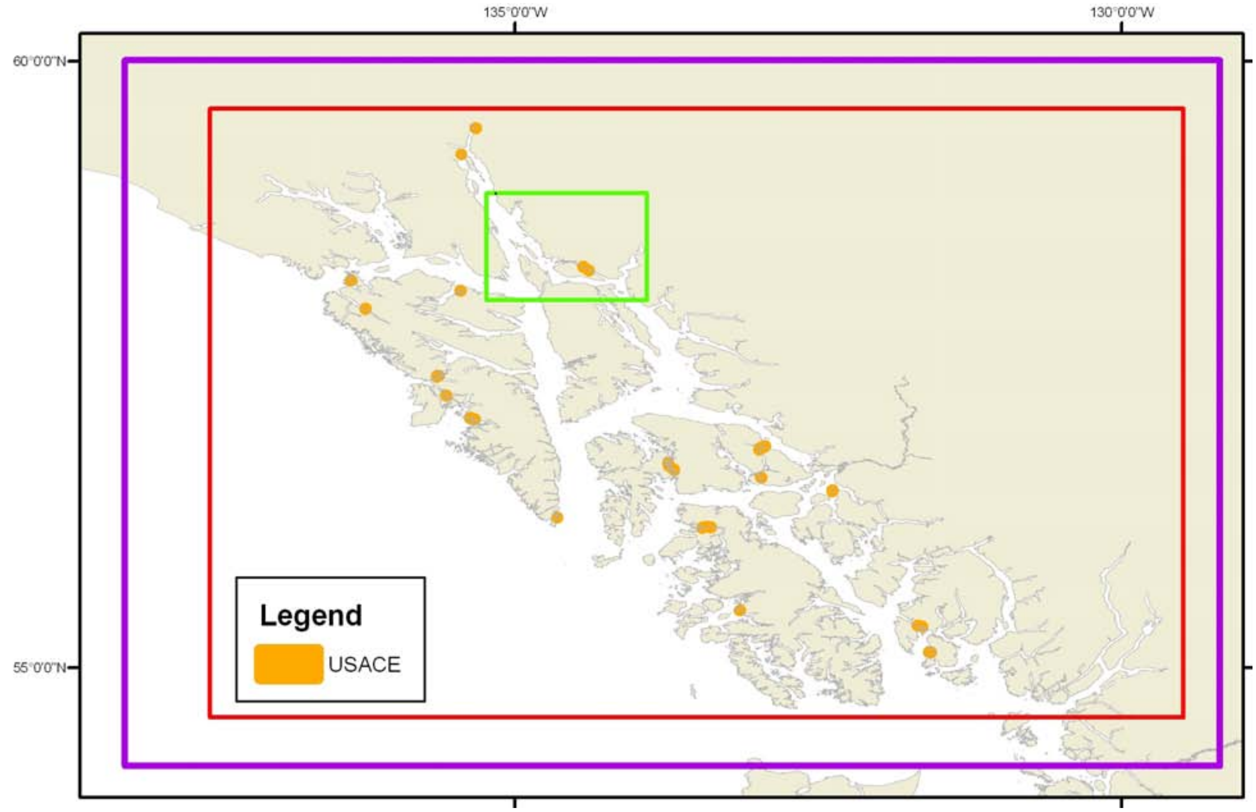

Figure 13. Spatial coverage of USACE hydrographic survey data in the Southeast Alaska region. Land areas shown in tan. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are also shown.

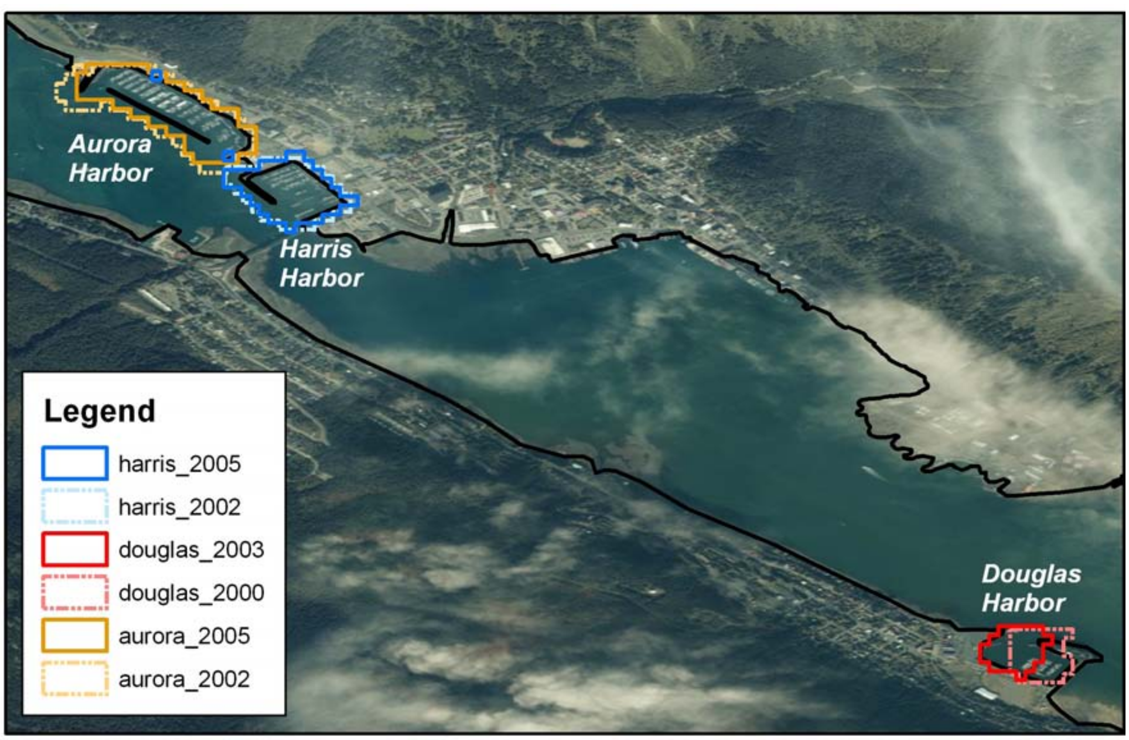

Figure 14. Spatial coverage of USACE hydrographic survey data in the vicinity of Juneau. ESRI World 2D Imagery shown in the background.

4) Electronic navigation chart soundings

Soundings from thirty-seven ENCs were used to supplement other bathymetric data, particularly in the deep water (Fig. 15; Appendix A). The ENCs were downloaded from NOAA's Office of Coast Survey web site and were horizontally referenced to NAD 83 geographic. ENC soundings were included in the gridding process only in regions where higher resolution and/or newer datasets were unavailable. The extracted soundings were transformed from a vertical datum of MLLW to MHHW (see Section 3.2.1).

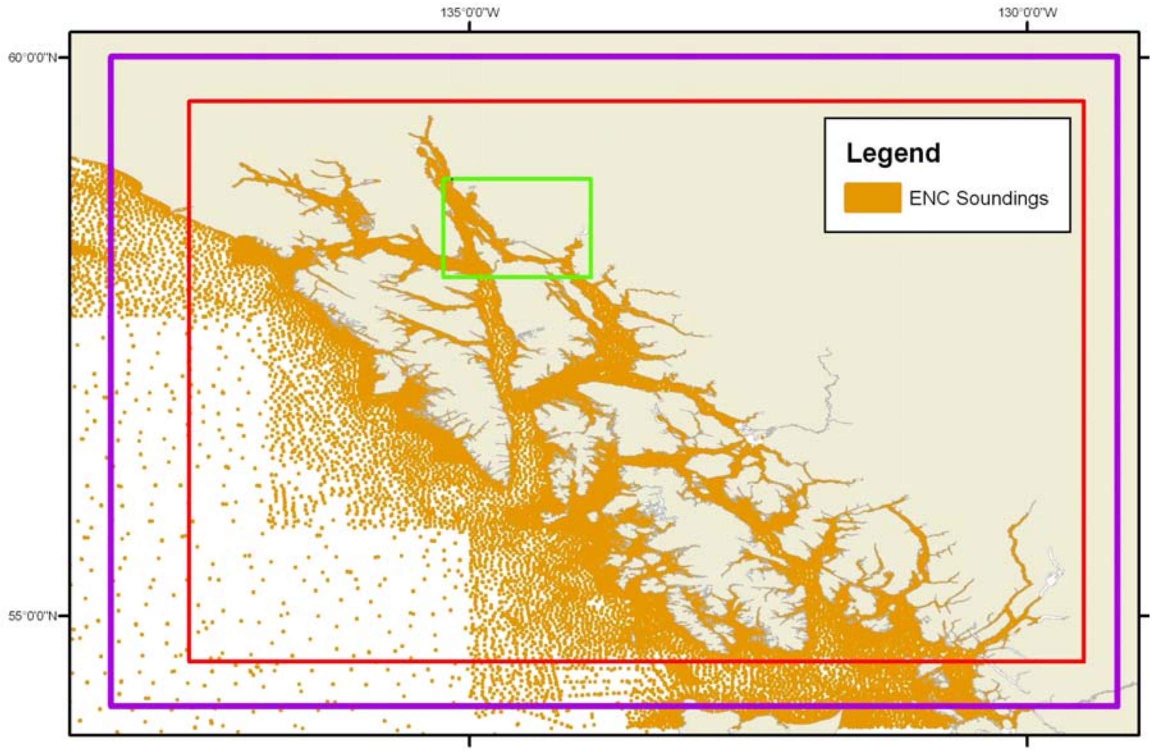

Figure 15. Spatial coverage of ENC soundings in the Southeast Alaska region. Land areas shown in tan. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are also shown.

5) **Trackline data files**

Fifty-three trackline surveys (Table 6) were available from the NGDC trackline survey database for use in building the Southeast Alaska DEMs. The Marine Trackline Geophysics database contains bathymetry, magnetics, gravity, and seismic navigation data collected during marine cruises from 1953 to the present. All surveys have a horizontal datum of WGS 84 geographic and undefined vertical datum, assumed to be MSL. The downloaded data in xyz format were converted to shapefiles and transformed to MHHW using the method described in Section 3.2.1. Trackline survey data were used to supplement other bathymetric data, particularly in the deep water, where limited data existed.

Table 6. NGDC trackline surveys used in compiling the Southeast Alaska DEMs.

Survey ID	*Source*	*Year*
17473	Defense Mapping Agency (DMA)	1970
26180	DMA	1980
26684	DMA	1984
66008	Geological Survey of Canada (GSC)	1966
67016	GSC	1967
76810	GSC	1976
78110	GSC	1978
81910	GSC	1981
82110	GSC	1982
ACO65SEP	Oregon State University (OSU)	1965
AT3L37	WHOI	1999
BA933001	US Navy	1972
DSDP18GC	SIO	1971
FARN0789	Natural Environment Research Council	1989
FOCI93	NOS	1993
G175EG	USGS	1975
G178EG	USGS Branch of Pacific Marine Geology (BPMG)	1978
L378EG	USGS BPMG	1978
L476WG	USGS BPMG	1976
L677EG	USGS	1977
LSSALE55	Minerals Management Service	1979
N180EG	USGS BPMG	1980
N184EG	USGS BPMG	1984
PGCP7910	GSC	1979
PGCPZ802	GSC	1980
PGCPZ811	GSC	1981

Survey ID	*Source*	*Year*
POL6402	NOAA	1964
POL6769	NOAA	1967
POL6971	NOAA	1969
POL6991	NOAA	1969
POL7001	NOS	1970
POL7103	NOAA	1971
POL7106	NOAA	1971
PZ72000	CHS	1972
RC1109	LDEO	1967
RC1407	LDEO	1971
RITS93C	NOS	1993
S1179EG	USGS BPMG	1979
S176EG	USGS BPMG	1976
S277EG	USGS BPMG	1977
S578EG	USGS BPMG	1978
S678EG	USGS BPMG	1978
S679NP	USGS BPMG	1979
SI933001	US Navy	1972
VIT29A	Vernadsky Institute for Geochemistry	1959
YAQ65JUL	OSU	1965
YAQ66JUL	OSU	1966
YAQ67AUG	OSU	1967
YAQ68SEP	OSU	1968
YAQ702	OSU	1970
YAQ703	OSU	1970
YAQ704	OSU	1970
YAQ705	OSU	1970

6) City of Juneau Harbor Surveys

Two harbor surveys were available from the City of Juneau Harbor Commission for use in building the Southeast Alaska DEMs (Fig. 16). The surveys were conducted in 2010 by R & M Engineering for improvement project plans of the Cruise Ship Docking Facility and the Steamship Docking Facility. The data include depths to approximately 100 feet and were provided to NGDC by Port Engineer Gary Gillette with the City of Juneau. The original horizontal and vertical datums were NAD 83 Alaska State Plane Zone I (feet) and MLLW, respectively. Horizontal datum conversions were accomplished using *Proj4*; vertical transformations were performed using the method described in Section 3.2.1.

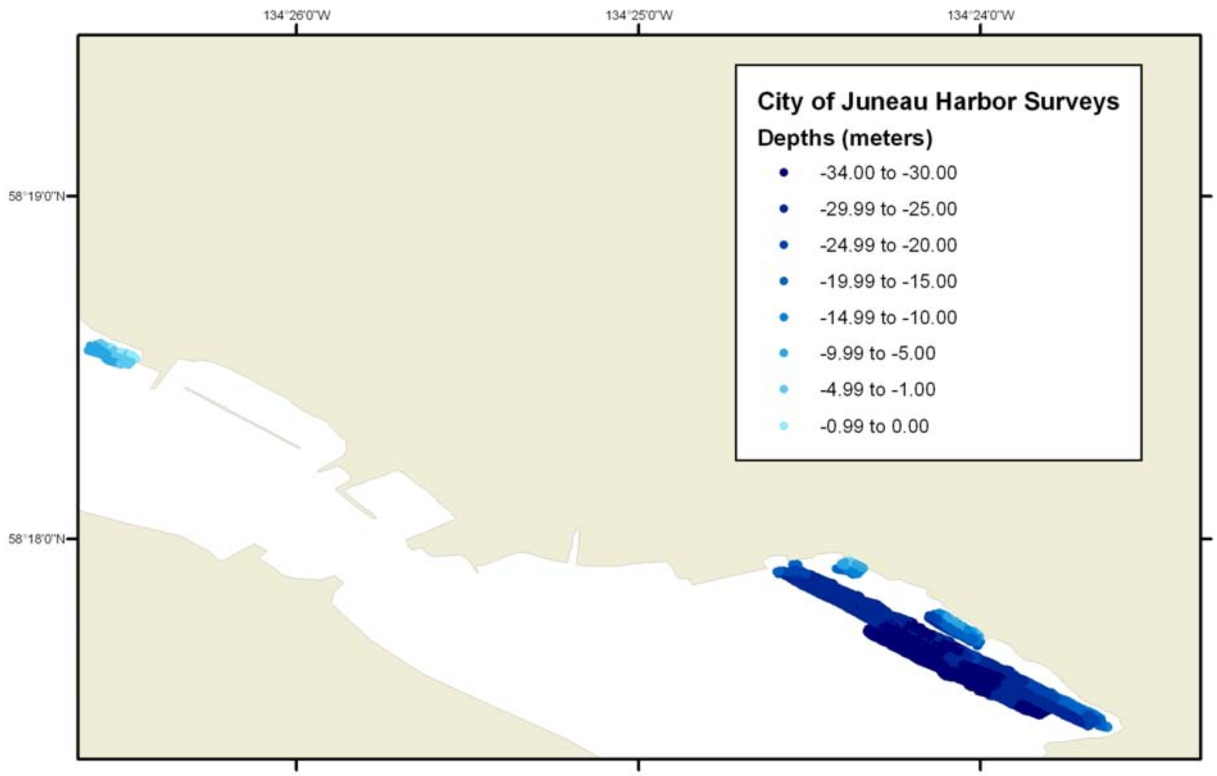

Figure 16. Spatial coverage of the City of Juneau harbor surveys. Land areas shown in tan. Coastline in grey.

7) Canadian Hydrographic Service gridded bathymetry

The CHS provided NGDC with gridded bathymetric data from Canadian hydrographic surveys that included regions in the southern portions of the Southeast Alaska 8 and 8/3 arc-second DEMs (Fig. 17). The gridded bathymetry data were provided to NGDC in point shapefile format at a resolution of 500 meters. The shapefile was converted to xyz format and clipped in regions of newer and higher resolution datasets using *GDAL* and *OGR*. The data were originally in NAD 83 Albers Conical Equal Area - British Columbia horizontal datum and undefined vertical datum, assumed to be MSL.

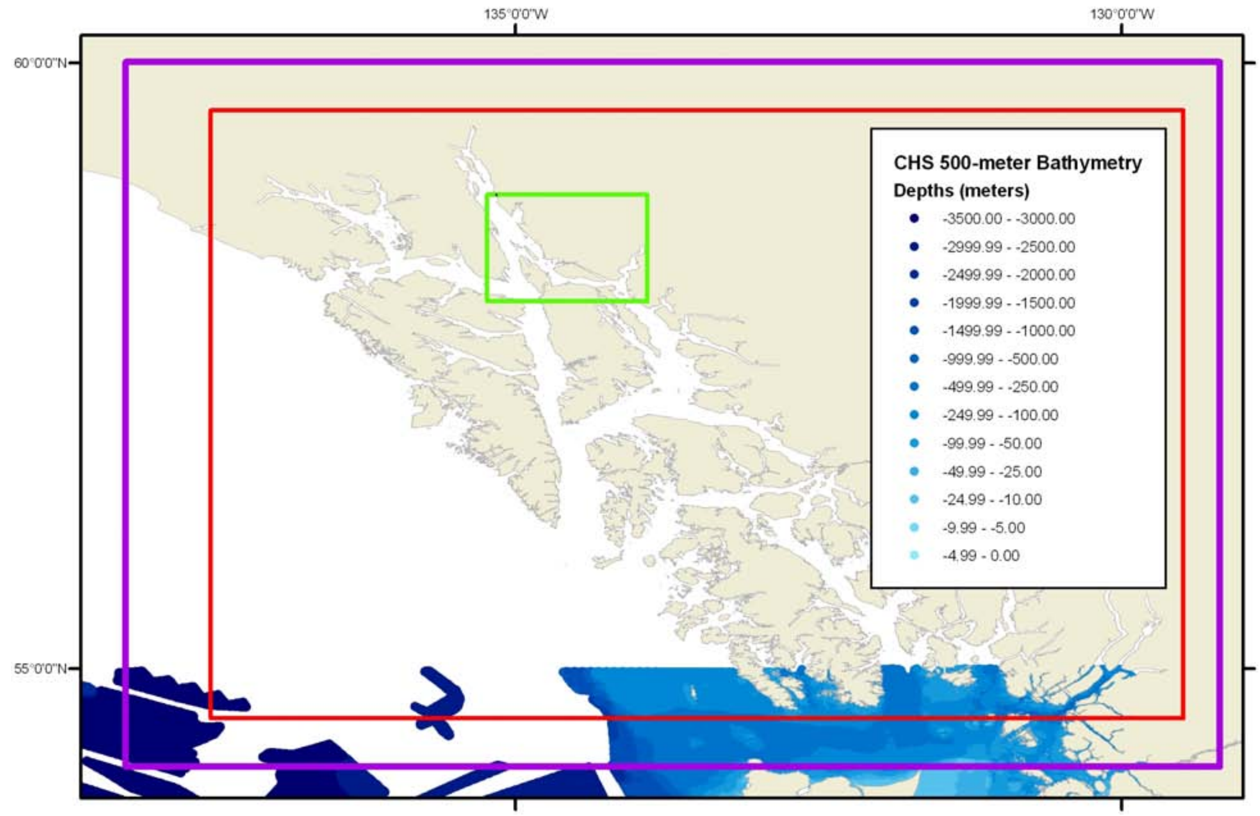

Figure 17. Spatial coverage of the CHS gridded bathymetry. Land areas shown in tan. Coastline in grey. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are also shown.

1.1.3 Topography

Topographic datasets of the Southeast Alaska region were obtained from the USGS and the NASA Jet Propulsion Laboratory (Table 7; Fig. 18). In addition, NGDC digitized elevation points to better represent several breakwaters, jetties, and bridge pilings along Gastineau Channel in the vicinity of Juneau as they were not resolved completely in the other topographic datasets.

NGDC reviewed the USGS National Elevation Dataset (http://ned.usgs.gov/) 2 arc-second gridded topography. The dataset was derived from USGS quadrangle maps and aerial photographs based on topographic surveys conducted in the 1970s and 1980s. The NED data were not used in the development of the Southeast Alaska DEMs due to: morphological changes in regions of rapid deglaciation across Alaska; lateral shifts in the NED discovered during prior DEM development in Alaska (see Caldwell et al., 2011 for further details); and lower resolution than other available topographic datasets.

NGDC also received topographic lidar from the U.S. Forestry Service in Juneau; however, these data were of high resolution over extremely small regions and greatly degraded the continuity of the topographic surfaces in the DEM. There was a single lidar survey within the 8/15 arc-second Juneau extents in the vicinity of the Mendenhall Glacier, well-displaced from the coast. While not used in the development of the current Southeast Alaska DEMs, the data may prove extremely useful in future high-resolution DEMs in the Southeast Alaska region. The data were provided to NGDC by Mark Riley of the USFS.

Table 7. Topographic datasets used in compiling the Southeast Alaska DEMs.

Source	*Year*	*Data Type*	*Spatial Resolution*	*Original Horizontal Datum*	*Original Vertical Datum*	*URL*
NASA SRTM	2000	Topographic DEM	1 arc-second	WGS 84 geographic	WGS 84/ EGM 96 Geoid (meters)	http://srtm.usgs.gov/
NASA ASTER	2009	Topographic DEM	1 arc-second	WGS 84 geographic	WGS 84/ EGM 96 Geoid (meters)	http://asterweb.jpl.nasa.gov/
NGDC	2009	Digitized elevation points	~ 10 meters	WGS 84 geographic	MHHW	

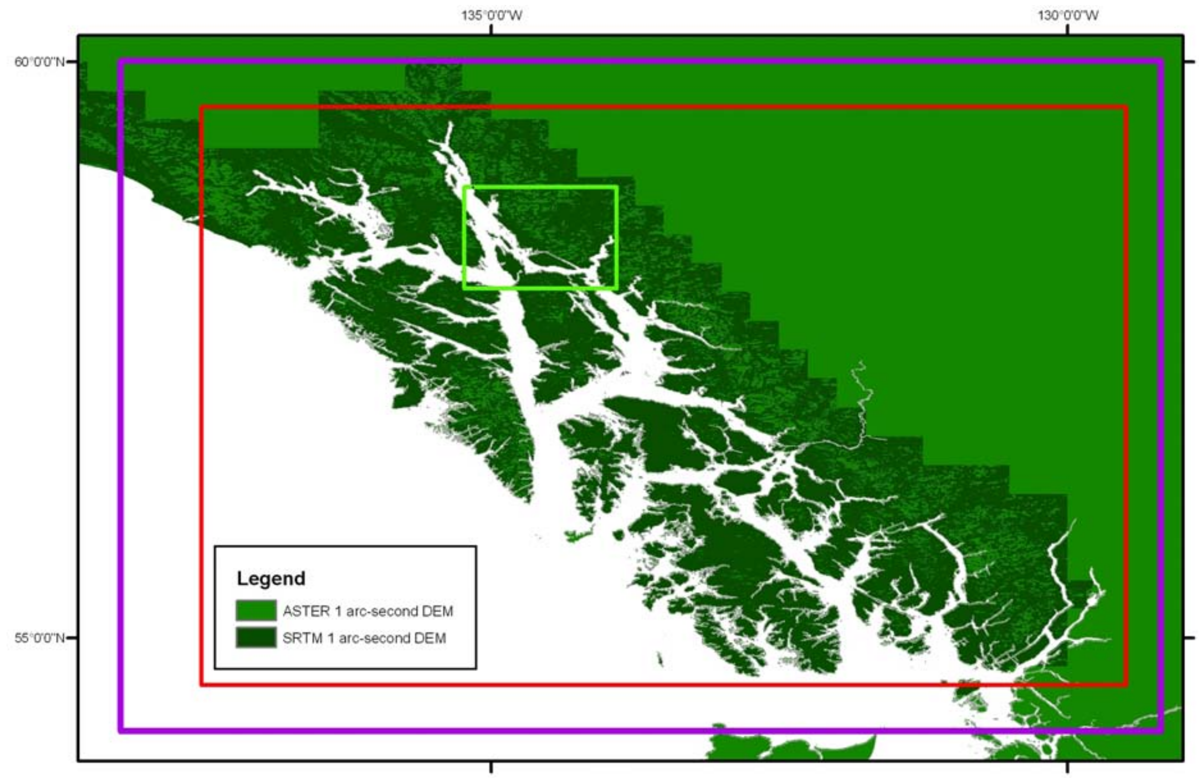

Figure 18. Source and coverage of topographic datasets used in compiling the Southeast Alaska DEMs. Light green areas (ASTER) within the darker green areas (SRTM) indicate 'no data' values in the SRTM. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are also shown. Areas of water indicated in white.

1) NASA space shuttle radar topography

The NASA Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale (60° S to 60° N) to generate a complete high-resolution digital topographic database of Earth[10]. The SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavour during an 11-day mission in February of 2000. Data from this mission have been processed into 1 degree × 1 degree tiles that have been edited to define the coastline, and are available from the USGS as raster DEMs. The data have not been processed to bare earth, but meet the absolute horizontal and vertical accuracies of 20 and 16 meters, respectively.

For the Southeast Alaska region, the data have 1 arc-second spacing and are referenced to the WGS 84/ EGM 96 Geoid. The SRTM provides nearly complete coverage of Prince William Sound but exhibits numerous small areas with "no data" values necessitating the use of the ASTER data in these areas (see Fig. 18). The SRTM DEM also contains values over the open ocean, which were deleted by clipping the data to the final coastline.

10. The SRTM data sets result from a collaborative effort by the National Aeronautics and Space Administration (NASA) and the National Geo-spatial-Intelligence Agency (NGA – previously known as the National Imagery and Mapping Agency, or NIMA), as well as the participation of the German and Italian space agencies, to generate a near-global digital elevation model (DEM) of the Earth using radar interferometry. The SRTM instrument consisted of the Spaceborne Imaging Radar-C (SIR-C) hardware set modified with a Space Station-derived mast and additional antennae to form an interferometer with a 60 meter long baseline. A description of the SRTM mission can be found in Farr and Kobrick (2000). Synthetic aperture radars are side-looking instruments and acquire data along continuous swaths. The SRTM swaths extended from about 30 degrees off-nadir to about 58 degrees off-nadir from an altitude of 233 km, and thus were about 225 km wide. During the data flight the instrument was operated at all times the orbiter was over land and about 1000 individual swaths were acquired over the ten days of mapping operations. Length of the acquired swaths range from a few hundred to several thousand km. Each individual data acquisition is referred to as a "data take." SRTM was the primary (and pretty much only) payload on the STS-99 mission of the Space Shuttle Endeavour, which launched February 11, 2000 and flew for 11 days. Following several hours for instrument deployment, activation and checkout, systematic interferometric data were collected for 222.4 consecutive hours. The instrument operated almost flawlessly and imaged 99.96% of the targeted landmass at least one time, 94.59% at least twice and about 50% at least three or more times. The goal was to image each terrain segment at least twice from different angles (on ascending, or north-going, and descending orbit passes) to fill in areas shadowed from the radar beam by terrain. This 'targeted landmass' consisted of all land between 56 degrees south and 60 degrees north latitude, which comprises almost exactly 80% of Earth's total landmass. [Extracted from SRTM online documentation]

2) NASA ASTER topography

ASTER provides complete 1 arc-second topographic data coverage of Alaska[11]. Data are in WGS 84 geographic coordinates and vertically referenced to the WGS 84/EGM 96 Geoid. The dataset is available for download as 1 degree x 1 degree raster files. The extracted non-bare-earth elevations have a vertical accuracy of +/- 20 meters and horizontal accuracy of +/- 30 meters, both at the 95 percent confidence level.

The ASTER data contain values over the open ocean, which were deleted by clipping the data to the final coastline. As discussed, the ASTER data was used to fill "no data" regions within the SRTM dataset (see Fig. 18). The ASTER data were not used as the primary topographic dataset due to the improper representation of areas along the immediate coastline. NGDC considered the SRTM to be most representative of the current coastal morphology, particularly in the immediate vicinity of Juneau.

Figure 19. NGDC-digitized elevation points in the vicinity of Juneau. Breakwaters, bridge supports, and control points were digitized at 1 meter elevation. Background image is from ESRI World 2D Imagery.

3) NGDC-digitized elevation points

Several jetties, breakwaters, and large bridge pilings were not resolved completely in the topographic datasets. Using the nearby elevations from SRTM and ASTER, a point shapefile was created using elevations of 1 or 1.5 meters at MHHW to best represent these features in the final DEMs (e.g., Fig. 19).

11. ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an imaging instrument flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System (EOS). ASTER is a cooperative effort between NASA, Japan's Ministry of Economy, Trade and Industry (METI) and Japan's Earth Remote Sensing Data Analysis Center (ERSDAC). ASTER is being used to obtain detailed maps of land surface temperature, reflectance and elevation. The three EOS platforms are part of NASA's Science Mission Directorate and the Earth-Sun System, whose goal is to observe, understand, and model the Earth system to discover how it is changing, to better predict change, and to understand the consequences for life on Earth. METI and NASA announced the release of the ASTER Global Digital Elevation Model (GDEM) on June 29, 2009. The GDEM was created by stereo-correlating the 1.3 million scene ASTER visible and near-infrared (VNIR) archive, covering the Earth's land surface between 83 N and 83 S latitudes. The GDEM is produced with 30 meter postings, and is formatted in 1 x 1 degree tiles as GeoTIFF files. Each GDEM file is accompanied by a Quality Assessment file, either giving the number of ASTER scenes used to calculate a pixel's value, or indicating the source of external DEM data used to fill the ASTER voids [Extracted from NASA JPL ASTER web site]

1.2 Establishing Common Datums

1.2.1 Vertical datum transformations

Datasets used in the compilation and evaluation of the Southeast Alaska DEMs were originally referenced to a number of vertical datums including MLLW (feet and meters), MLW, MSL, MHW, WGS 84/EGM 96 Geoid, and undefined (assumed to be MSL). All datasets were transformed to MHHW for modeling of maximum flooding. Vertical datum transformations to MHHW were accomplished using *FME* and *GDAL*, based upon data from tide stations, a DART buoy, and dominant tidal components (Brown et al., 1989) in the region.

NGDC created two offset grids approximating the relationship between MHHW and MLLW, and MHHW and MSL for the Southeast Alaska region. The grids were built in *ArcGIS* using the 'Kriging' tool and the differences, in meters, between the vertical datums as measured at 8 NOAA tide stations (http://tidesandcurrents.noaa.gov/), 10 tide prediction sites (http://co-ops.nos.noaa.gov/tides05/tab2wc2b.html), one deep-ocean DART buoy (http://www.ndbc.noaa.gov/dart.shtml), and 74 CHS tide stations (Table 8; Figs. 20 and 21). In addition, NGDC digitized 44 control points along the grid edges to constrain the interpolation. The differences in vertical datums at the control points were assigned using the available tide stations, DART buoy, and a diagram of the dominant semi-diurnal lunar tidal component (see page 55, Fig. 2.9 from Brown et al., 1989). In using the differences between the vertical datums, the final offsets grids contained negative values (Figs. 20 and 21). The offset grids span from ~143.81º W to ~128.12º W and ~51.00º N to ~61.50º N with a grid cell size of 8 arc-seconds or 0.00222222 degrees.

1) Bathymetric data

The NOS hydrographic surveys (except for H03680 and H02333), multibeam swath sonar surveys, ENC soundings, USACE surveys, trackline surveys, City of Juneau harbor surveys, and CHS gridded bathymetry were transformed from either MSL to MHHW or MLLW to MHHW by adding the corresponding grid value to the point elevation value using *GDAL* . For the two remaining MLW surveys, NGDC first converted the surveys to MHHW using the MLLW-to-MHHW offset grid and then adjusted the values by +0.41, the average difference between MLLW and MLW at the NOAA tide stations, tide prediction sites, and DART buoy. The CHS tide station information did not provide values for MLW or MHW.

2) Topographic data

The topographic datasets were originally referenced to WGS 84/EGM 96 Geoid. There are no survey markers in Southeast Alaska that relate the geodetic datum to local tidal datums. Therefore, it was assumed that the datum is essentially equivalent to MSL in this area. Conversion to MHHW, using *GDAL*, was accomplished by adding the MSL-to-MHHW offset grid. Values less than 1 meter following the conversion were set equal to 1 meter, as both the SRTM and ASTER data are in integer format.

Table 8. Relationship between MHHW and other vertical datums in the Southeast Alaska region.

Name	*ID*	*Type*	*Source*	*Longitude*	*Latitude*	*MLLW*	*MLW*	*MSL*	*MHW*	*MHHW*
Baranof Warm Spring	9451625	TPS	NOAA	-134.825000	57.088333	1.501	1.971	3.713	5.428	5.701
Big Salt Lake	9450623	TPS	NOAA	-132.950000	55.600000	17.437	17.466	17.904	18.363	18.601
Craig	9450551	TPS	NOAA	-133.141667	55.488333	1.606	2.024	3.233	4.448	4.707
DART 46410	46410	DART	NOAA	-143.804000	57.634000	0.000	---	1.554	---	2.950
Elfin Cove	9452634	TS	NOAA	-136.346667	58.193333	2.878	3.326	4.635	5.977	6.251
Entrance Island	9451438	TPS	NOAA	-133.786667	56.811667	-1.022	-0.552	1.301	3.155	3.416
False Bay Chatham St	9452328	TPS	NOAA	-134.935000	57.966667	0.189	0.678	2.614	4.503	4.786
Juneau	9452210	TS	NOAA	-134.411667	58.298333	1.102	1.590	3.712	5.778	6.073
Ketchikan	9450460	TS	NOAA	-131.625000	55.331667	1.887	2.366	4.345	6.320	6.595
Magnetic Point Union	9450753	TPS	NOAA	-132.190000	55.788333	-2.349	-1.873	0.190	2.268	2.539
Monte Carlo Island	9451247	TPS	NOAA	-133.766667	56.535000	1.268	1.718	3.281	4.874	5.129
Port Alexander	9451054	TS	NOAA	-134.646667	56.246667	1.111	1.555	2.865	4.191	4.454
Sitka	9451600	TS	NOAA	-135.341667	57.051667	1.379	1.824	2.989	4.170	4.407
Skagway	9452400	TS	NOAA	-135.326667	59.450000	0.811	1.304	3.494	5.606	5.911
Target Island Mitche	9451953	TPS	NOAA	-134.416667	57.533333	15.559	15.881	17.302	18.697	18.975
The Summit	9451349	TPS	NOAA	-133.736667	56.681667	-0.992	-0.500	1.457	3.373	3.639
Trocadero Bay	9450463	TS	NOAA	-132.936667	55.351667	0.186	0.599	1.798	3.011	3.259
Turn Point	9451434	TPS	NOAA	-132.980000	56.800000	-1.152	-0.694	1.389	3.479	3.746
Yakutat	9453220	TS	NOAA	-139.733333	59.548333	0.550	0.975	2.159	3.357	3.620
Alice Arm	9448	TS	CHS	-129.483333	55.466667	1.270	---	3.954	---	6.290
Armentieres Channel	9605	TS	CHS	-132.383333	53.100000	0.960	---	2.526	---	3.770
Atli Inlet	9765	TS	CHS	-131.576667	52.713333	1.010	---	3.180	---	5.040
Barnard Harbour	9115	TS	CHS	-129.116667	53.083333	0.810	---	3.080	---	5.040
Beauchemin Channel	9082	TS	CHS	-129.298667	52.781333	0.960	---	3.050	---	4.850
Block Islands	9165	TS	CHS	-129.733333	53.150000	0.860	---	3.048	---	4.960
Borrowman Bay	9080	TS	CHS	-129.266667	52.733333	0.650	---	2.801	---	4.620
Brundige Inlet	9333	TS	CHS	-130.851817	54.614383	1.150	---	3.640	---	5.750
Butedale	9053	TS	CHS	-128.683333	53.150000	0.900	---	3.050	---	4.960
Casey Cove	9350	TS	CHS	-130.366667	54.266667	1.160	---	3.810	---	6.130
Claxton	9260	TS	CHS	-130.083333	54.066667	1.210	---	3.781	---	6.120
Dadens	9960	TS	CHS	-132.983333	54.183333	1.010	---	2.913	---	4.510
Davis River	9470	TS	CHS	-130.166667	55.766667	-0.170	---	2.621	---	5.030
Dawson Harbour	9635	TS	CHS	-132.459000	53.163000	0.740	---	2.370	---	3.680
Gillen Harbour	9105	TS	CHS	-129.600000	52.966667	0.970	---	3.103	---	4.950
Granby Bay	9443	TS	CHS	-129.816667	55.400000	1.170	---	3.834	---	6.120
Griffin Pass	9020	TS	CHS	-128.333333	52.766667	0.870	---	2.804	---	4.440
Griffith Harbour	9230	TS	CHS	-130.533333	53.583333	1.030	---	3.553	---	5.790
Hartley Bay	9130	TS	CHS	-129.233333	53.416667	0.900	---	3.170	---	5.140
Haysport	9266	TS	CHS	-130.000000	54.166667	1.230	---	3.840	---	6.150
Henslung Cove	9958	TS	CHS	-133.004167	54.191667	0.940	---	2.780	---	4.330
Higgins Passage	9056	TS	CHS	-128.750000	52.483333	1.040	---	2.930	---	4.540
Hudson Bay Passage	9329	TS	CHS	-130.850000	54.450000	0.980	---	3.460	---	5.580
Humpback Bay	9309	TS	CHS	-130.383333	54.083333	1.220	---	3.697	---	5.770
Hunger Harbour	9570	TS	CHS	-132.033333	52.750000	0.730	---	2.328	---	3.650
Hunt Inlet	9310	TS	CHS	-130.433333	54.066667	1.120	---	3.794	---	6.040

Name	*ID*	*Type*	*Source*	*Longitude*	*Latitude*	*MLLW*	*MLW*	*MSL*	*MHW*	*MHHW*
Juskatla	9927	TS	CHS	-132.316667	53.616667	0.070	---	0.610	---	1.290
Kemano Bay	9150	TS	CHS	-128.116667	53.466667	1.050	---	3.440	---	5.560
Khyex Point	9275	TS	CHS	-129.800000	54.233333	0.150	---	2.599	---	4.970
Kincolith	9422	TS	CHS	-129.966667	54.983333	0.980	---	3.691	---	6.000
Kitimat	9140	TS	CHS	-128.716667	53.983333	0.980	---	3.290	---	5.310
Kitkatla Islands	9242	TS	CHS	-130.350000	53.800000	1.040	---	3.660	---	5.930
Klemtu	9035	TS	CHS	-128.516667	52.583333	0.990	---	2.901	---	4.560
Kumeon Bay	9414	TS	CHS	-130.233333	54.700000	1.000	---	3.605	---	5.860
Kwinitsa River	9285	TS	CHS	-129.583333	54.216667	0.100	---	1.453	---	3.000
Langara Point	9964	TS	CHS	-133.033333	54.250000	0.850	---	2.770	---	4.360
Larsen Island	9232	TS	CHS	-130.566667	53.616667	1.370	---	3.780	---	5.980
Lawyer Island	9312	TS	CHS	-130.333333	54.100000	1.270	---	3.900	---	6.170
Lowe Inlet	9195	TS	CHS	-129.566667	53.550000	1.080	---	3.453	---	5.520
Masset	9910	TS	CHS	-132.149317	54.009683	0.480	---	2.040	---	3.420
McCoy Cove	9790	TS	CHS	-131.650000	53.033333	1.020	---	3.277	---	5.180
McKenney Island	9077	TS	CHS	-129.483333	52.650000	0.860	---	2.830	---	4.530
McPherson Point	9963	TS	CHS	-132.966667	54.233333	0.610	---	2.493	---	4.010
Meyers Narrows	9060	TS	CHS	-128.616667	52.600000	0.740	---	2.743	---	4.490
Mill Bay	9425	TS	CHS	-129.883333	54.983333	0.800	---	3.374	---	5.640
Milne Island	9063	TS	CHS	-128.766667	52.600000	0.920	---	2.910	---	4.640
Moffat Islands	9325	TS	CHS	-130.716667	54.433333	1.080	---	3.581	---	5.710
Morse Basin	9344	TS	CHS	-130.233333	54.250000	0.120	---	2.166	---	4.300
Pacofi Bay	9775	TS	CHS	-131.866667	52.816667	1.310	---	3.510	---	5.400
Port Clements	9920	TS	CHS	-132.183333	53.683333	0.200	---	1.311	---	2.370
Port Edward	9342	TS	CHS	-130.283333	54.216667	1.100	---	3.711	---	5.950
Port Louis	9671	TS	CHS	-132.950000	53.683333	0.840	---	2.530	---	3.880
Port Simpson	9390	TS	CHS	-130.416667	54.550000	1.220	---	3.851	---	6.070
Prince Rupert	9354	TS	CHS	-130.316667	54.316667	1.150	---	3.849	---	6.160
Qlawdzeet Anchorage	9315	TS	CHS	-130.766667	54.200000	1.130	---	3.690	---	5.860
Queen Charlotte	9850	TS	CHS	-132.066667	53.250000	1.170	---	3.992	---	6.320
Ranger Islet	9418	TS	CHS	-130.166667	54.833333	1.140	---	3.733	---	5.950
Refuge Bay	9306	TS	CHS	-130.533333	54.050000	1.150	---	3.753	---	6.000
Salmon Cove	9435	TS	CHS	-129.833333	55.250000	1.040	---	3.666	---	5.970
Seabreeze Point	9250	TS	CHS	-130.166667	53.983333	1.220	---	3.731	---	6.020
Seal Cove	9360	TS	CHS	-130.266667	54.316667	1.140	---	3.780	---	6.090
Sedgwick Bay	9753	TS	CHS	-131.583333	52.633333	0.770	---	2.798	---	4.520
Shields Bay	9650	TS	CHS	-132.416667	53.300000	0.900	---	2.560	---	3.880
Shingle Bay	9808	TS	CHS	-131.816667	53.250000	1.190	---	4.008	---	6.390
Skidegate Channel East	9823	TS	CHS	-132.233333	53.150000	1.170	---	3.942	---	6.390
Skidegate Channel West	9830	TS	CHS	-132.266667	53.150000	0.370	---	2.084	---	3.650
Stewart	9475	TS	CHS	-130.000000	55.916667	1.170	---	3.947	---	6.420
Surf Inlet	9090	TS	CHS	-128.900000	53.016667	0.900	---	2.944	---	4.710
Trail Bay	9406	TS	CHS	-130.350000	54.583333	0.990	---	3.636	---	5.880
Trounce Inlet	9625	TS	CHS	-132.316667	53.133333	0.480	---	2.017	---	3.480
Wainright Basin	9343	TS	CHS	-130.250000	54.250000	0.230	---	2.218	---	4.380
Wiah Point	9940	TS	CHS	-132.300000	54.100000	0.960	---	3.078	---	4.880

TPS = Tide Prediction Site; TS= Tide Station

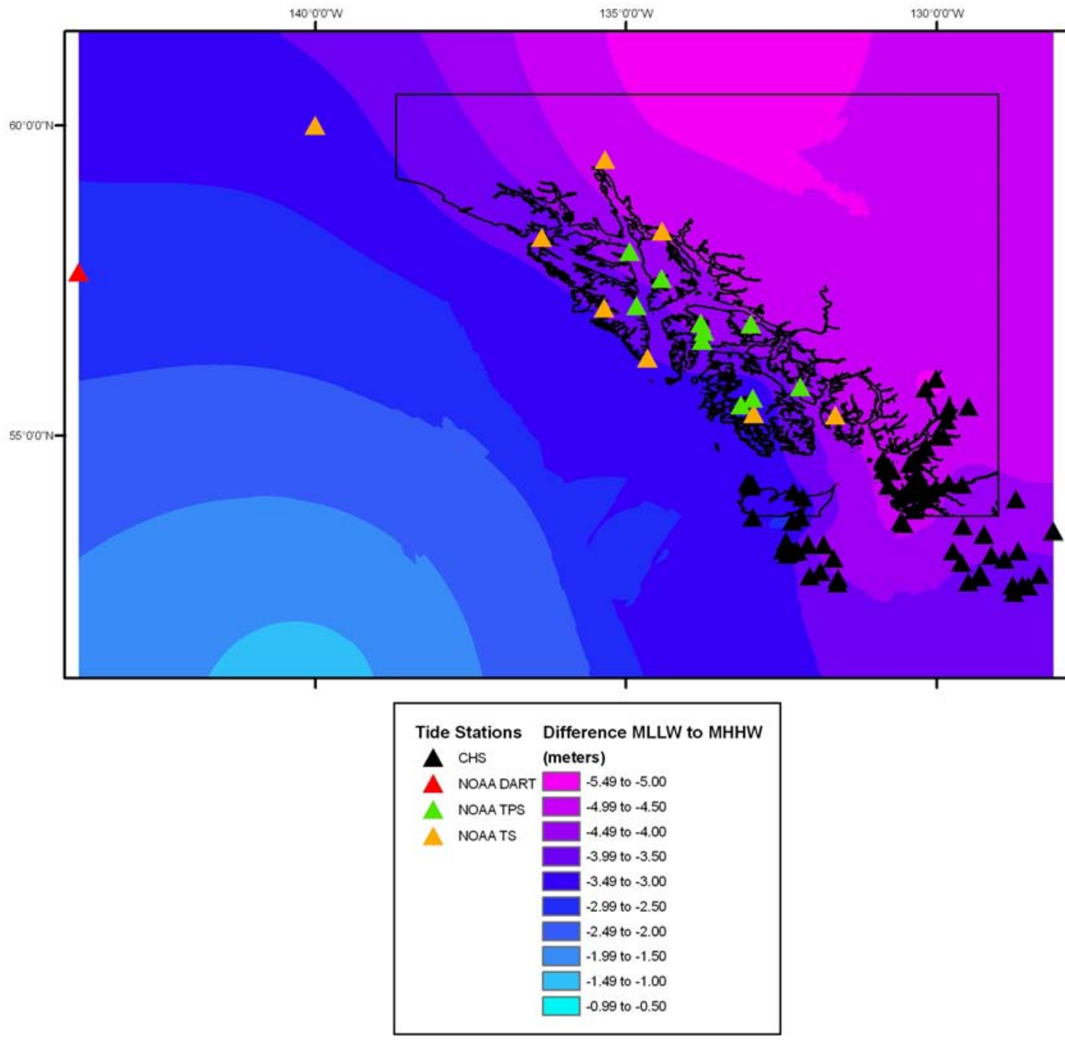

Figure 20. The MLLW-to-MHHW offset grid used to convert data between vertical datums. Tide stations, tide prediction sites, and DART buoy are shown. Coastline is in black.

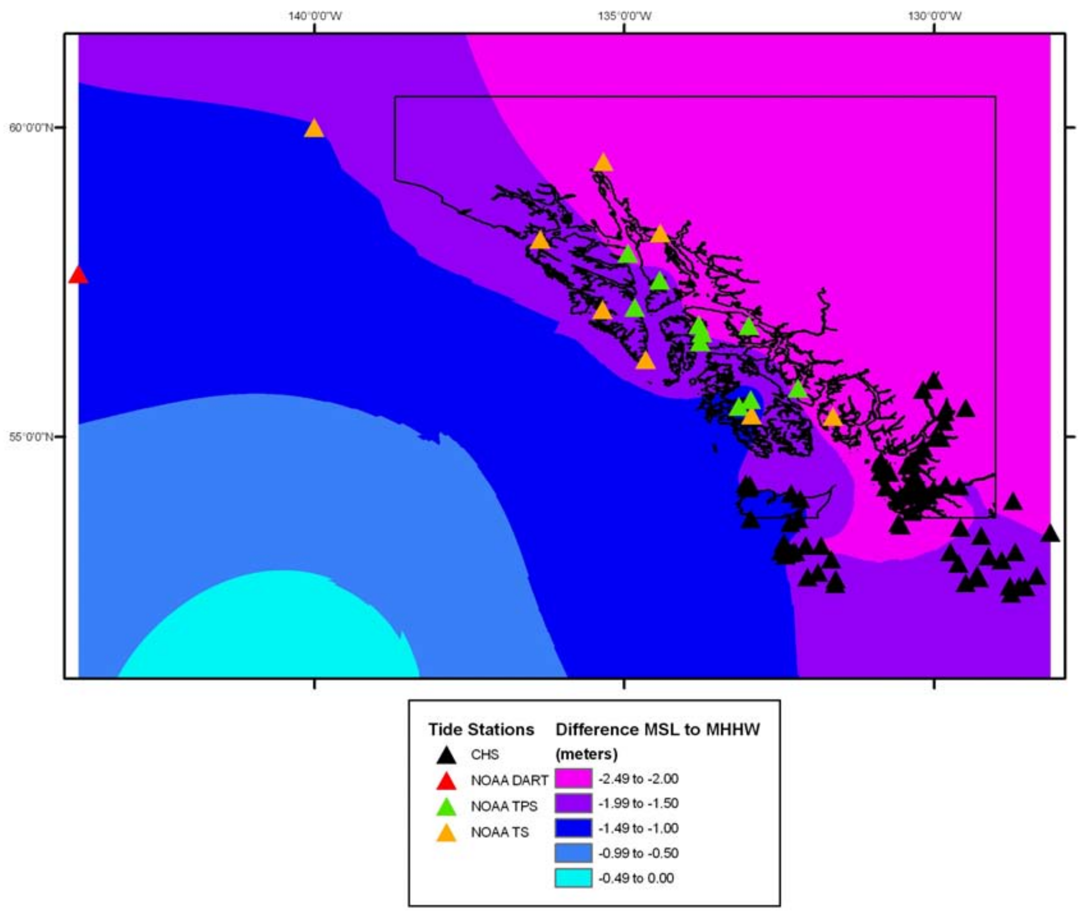

Figure 21. The MSL-to-MHHW offset grid used to convert data between vertical datums. Tide stations, tide prediction sites, and DART buoy are shown. Coastline is in black.

1.2.2 Horizontal datum transformations

Datasets used to compile the Southeast Alaska DEMs were originally referenced to WGS 84 geographic, NAD 83 geographic, NAD 83 UTM Zone 8 North, NAD 83 UTM Zone 9 North, NAD 83 Alaska State Plane Zone I (feet and meters), and Albers Conical Equal Area (British Columbia). The relationships and transformational equations between the geographic horizontal datums are well established. Transformations to NAD 83 geographic were accomplished using *Proj4*.

1.3 Digital Elevation Model Development

1.3.1 Verifying consistency between datasets

After horizontal and vertical transformations were applied, the resulting ESRI shapefiles were checked in *ArcMap* and *QT Modeler* for inter-dataset consistency. Problems and errors were identified and resolved before proceeding with subsequent gridding steps. The evaluated and edited ESRI shapefiles were then converted to xyz files in preparation for gridding. Problems included:

- Inconsistent, overlapping high-resolution bathymetric datasets. Older datasets were clipped to newer datasets when possible. Datasets were weighted based on quality and year during the gridding process.
- Data values over the ocean in the SRTM and ASTER DEM datasets. These datasets required automated clipping to the final coastline or were edited manually.
- Digital, measured bathymetric values from NOS surveys date back over 100 years. More recent data, such as the multibeam surveys, differed from older NOS data by as much as 70 meters vertically. The older NOS survey data were excised where more recent bathymetric data exists.
- Some breakwaters, jetties, and bridge pilings in Aurora, Douglas, and Harris Harbors near Juneau are not well-represented in available elevation data. Nearby elevation values from the SRTM and ASTER DEMs were used to estimate elevations at 1 or 1.5 meters for these features.
- Lack of bathymetric data in the delta regions of the Mendenhall and Stikine Rivers. An upper limit was set during the generation of the bathymetric surface to ensure depths near -0.50 meter in those regions.

1.3.2 Smoothing of bathymetric data

The older NOS hydrographic survey data, extracted ENC soundings, and NGDC trackline surveys are generally sparse at the resolution of the Southeast Alaska DEMs in both deep water and in some areas close to shore. In order to reduce the effect of artifacts in the form of lines or "pimples" in the DEM due to the low resolution datasets, and to provide effective interpolation into the coastal zone, 'pre-surface' bathymetric grids in MHHW vertical datum were generated using *GMT*[12], an NSF-funded software application designed to manipulate data for mapping purposes (http://gmt.soest.hawaii.edu/).

A Southeast Alaska 8 arc-second, 'pre-surface' grid was compiled from NOS hydrographic point data, USACE surveys, ENC soundings, City of Juneau harbor surveys, trackline surveys, CHS gridded bathymetry, and NGDC multibeam swath sonar bathymetry data by converting the files to xyz format. These xyz files were combined into a single file, along with points extracted every 10 meters from the final coastline. To provide a slightly negative buffer along the entire coastline, the extracted points were assigned values of -0.23 meter, the average difference between MHW and MHHW at the NOAA tide stations, to make sure that the offshore elevations remained negative; this was necessary due to the sparseness of the bathymetric data near the coast. These point data were then smoothed using the *GMT* tool 'blockmedian' onto a 8 arc-second grid. The *GMT* tool 'surface' was then applied to interpolate values for cells without data values. The *GMT* grid created by 'surface' was converted into an ESRI Arc ASCII grid file using the *MB-System* tool 'mbm_grd2arc' for viewing in ESRI *ArcMap*. *GDAL* software was used to clip the grid with the final coastline to eliminate data interpolation into land areas. Pre-surface grids for the 8/3 and 8/15 arc-second grids were built following the same methodology.

The 'pre-surfaces' were compared with the original soundings to ensure grid accuracy, converted to a shape file, and then exported as an xyz file for use in the final gridding process (Table 9). The statistical analyses of the differences between the 8/15 arc-second bathymetric surface at Juneau with the NOS hydrographic surveys and NGDC multibeam swath sonar surveys show that the majority of the surveys are in good agreement (Figs. 22 and 23) with the bathymetric surface. The few exceptions where the differences reached up to 36.13 meters are attributed to rugged bathymetry or overlapping datasets, where two or more closely positioned points were averaged to obtain the elevation of one grid cell. Some inconsistencies were identified while merging the bathymetric datasets due to the range in ages and resolutions of the surveys. In areas where more recent data were available, the older surveys were either edited or not used. The gridded bathymetric surfaces were then converted to xyz files for use in building the final DEMs.

12. GMT is an open source collection of ~60 tools for manipulating geographic and Cartesian data sets (including filtering, trend fitting, gridding, projecting, etc.), and producing Encapsulated PostScript File (EPS) illustrations ranging from simple x-y plots via contour maps to artificially illuminated surfaces and 3-D perspective views. GMT supports ~30 map projections and transformations and comes with support data such as GSHHS coastlines, rivers, and political boundaries. GMT is developed and maintained by Paul Wessel and Walter H. F. Smith with help from a global set of volunteers, and is supported by the National Science Foundation. It is released under the GNU General Public License. URL: http://gmt.soest.hawaii.edu/ [Extracted from GMT web site.]

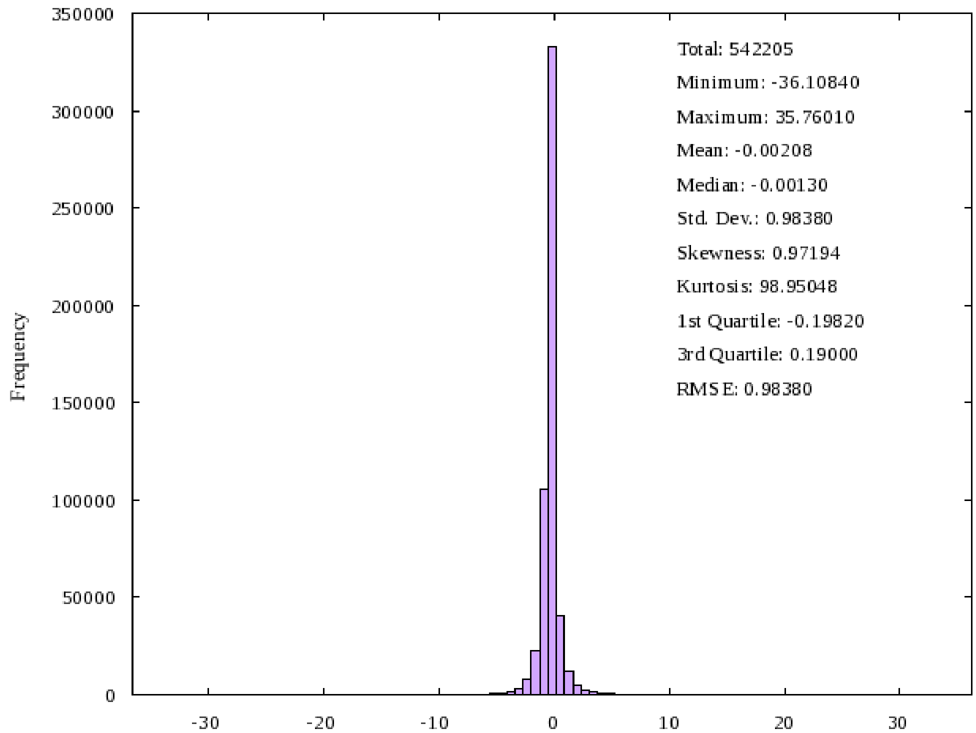

Figure 22. Histogram of the differences between NOS hydrographic surveys and the 8/15 arc-second pre-surfaced bathymetric grid.

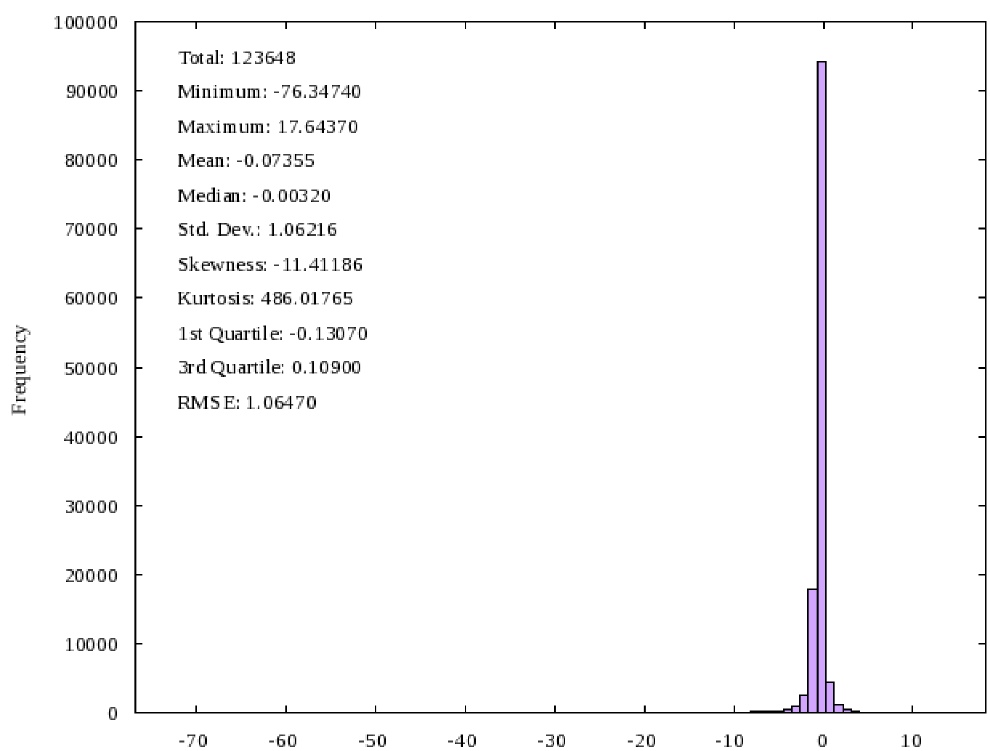

Figure 23. Histogram of the differences between NGDC multibeam swath sonar surveys and the 8/15 arc-second pre-surfaced bathymetric grid.

1.3.3 Building the DEMs using MB-System

MB-System was used to create the Southeast Alaska DEMs. The *MB-System* tool 'mbgrid' was used to apply a tight spline tension to the xyz data, and interpolate values for cells without data. The data hierarchy used in the 'mbgrid' gridding algorithm, as relative gridding weights, is listed in Table 9. Greatest weight was given to the high resolution multibeam surveys, NOS BAG data, USACE hydrographic surveys, and the NGDC digitized features. Least weight was given to the pre-surfaced bathymetric grid, NGDC trackline, CHS gridded bathymetry, and ENC soundings.

Table 9. Data hierarchy used to assign gridding weight in *MB-System*

Dataset	*Relative Gridding Weight*
NGDC multibeam	100
USACE hydrographic surveys	100
NOS ASCII	100
NOS BAG	100
NGDC digitized features	100
City of Juneau harbor surveys	10
NOS hydrographic surveys	10
ENC soundings	10
NASA SRTM	1
NASA ASTER	1
Pre-surfaced bathymetric grid	1
CHS gridded bathymetry	1
NGDC trackline	0.1

1.4 Quality Assessment of the DEMs

1.4.1 Horizontal accuracy

The horizontal accuracy of topographic and bathymetric features in the Southeast Alaska DEMs is dependent upon DEM cell size and source datasets. Topographic features have an estimated horizontal accuracy of 30 meters: SRTM has a horizontal accuracy of ~20 meters and ASTER, approximately 30 meters. Bathymetric features are resolved only to within a few hundreds of meters in deep-water areas. Shallow, near-coastal regions, rivers, and harbor surveys have an accuracy approaching that of sub-aerial topographic features. Positional accuracy is limited by the sparseness of deep-water soundings and potentially large positional uncertainty of pre-satellite navigated (e.g., GPS) NOS hydrographic surveys.

1.4.2 Vertical accuracy

Vertical accuracy of elevation values in the Southeast Alaska DEMs is also dependent upon the source datasets contributing to DEM cell values. Topographic data have an estimated vertical accuracy between 16 meters for the SRTM DEM and 20 meters for the ASTER DEM. Bathymetric values have an estimated accuracy between 0.1 meters and 5% of water depth. Those values were derived from the wide range of sounding measurements from the early 20^{th} century to recent, GPS-navigated multibeam swath sonar survey. Gridding interpolation to determine bathymetric values between sparse, poorly located NOS soundings degrades the vertical accuracy of elevations in deep water.

1.4.3 Slope map and 3-D perspectives

ESRI *ArcCatalog* was used to generate a slope grid from the 8/15 arc-second Juneau DEM to allow for visual inspection and identification of artificial slopes along boundaries between datasets (Fig. 24). The DEM was transformed to NAD 83 UTM Zone 8 North coordinates (horizontal units in meters) in *ArcCatalog* for derivation of the slope grid; equivalent horizontal and vertical units are required for effective slope analysis. Analysis of preliminary grids using *QT Modeler* and *Fledermaus* revealed suspect data points, which were corrected before recompiling the DEM. Figure 1 shows a color image of the 8 arc-second Southeast Alaska DEM in its final version. Figure 25 shows a perspective rendering of the final 8 arc-second Southeast Alaska DEM. Figure 26 shows a data contribution plot of the Southeast Alaska 8 arc-second DEM.

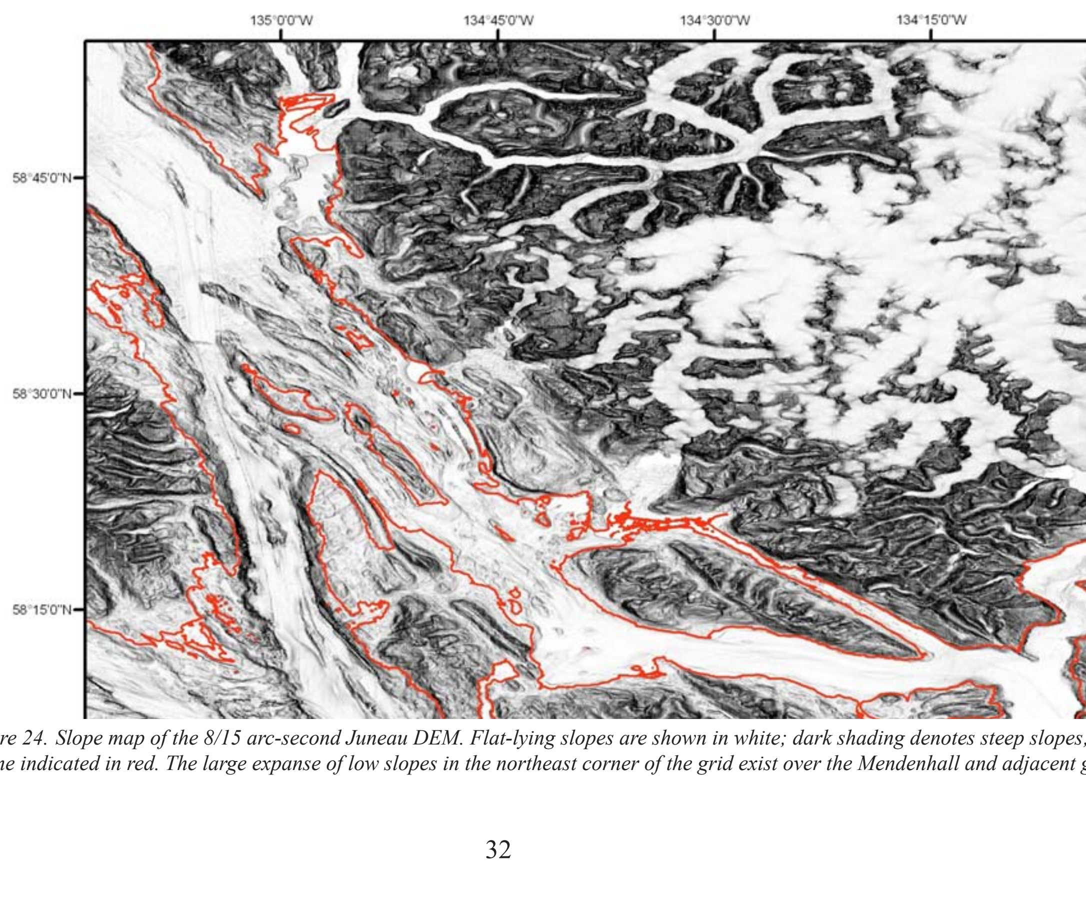

Figure 24. Slope map of the 8/15 arc-second Juneau DEM. Flat-lying slopes are shown in white; dark shading denotes steep slopes; final coastline indicated in red. The large expanse of low slopes in the northeast corner of the grid exist over the Mendenhall and adjacent glaciers.

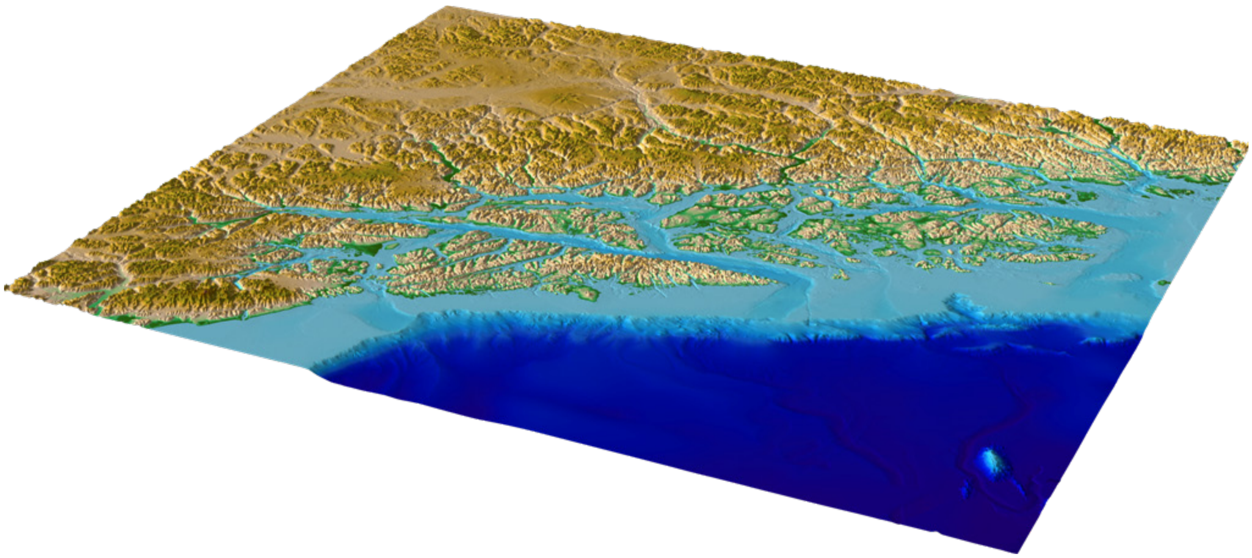

Figure 25. Perspective view from the southwest of the 8 arc-second Southeast Alaska DEM. Vertical exaggeration–times 2.

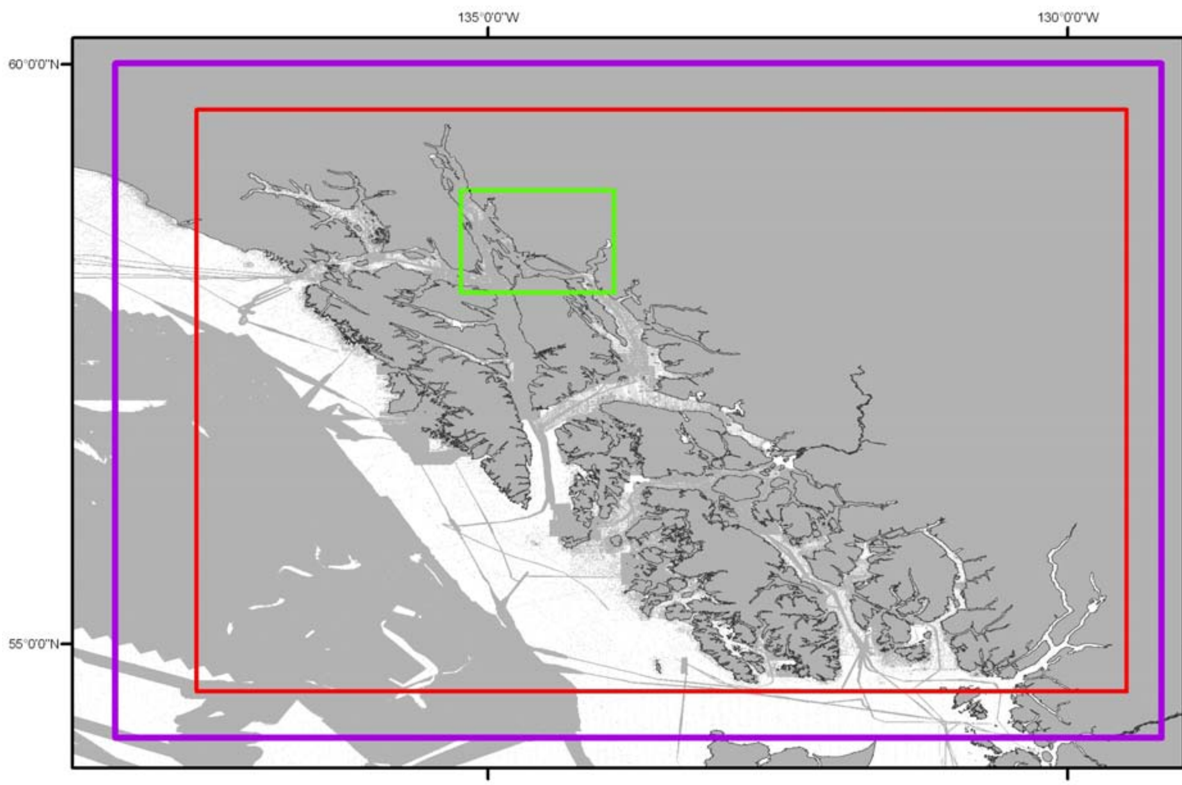

Figure 26. Data contribution plot of the 8 arc-second Southeast Alaska DEM. Grey depicts DEM cells constrained by source data; white depicts cells with elevation values derived from interpolation. Due to the scale of the image, sparse soundings may not be visible in the graphic. Coastline is shown in black. Extents of the 8 arc-second (purple), 8/3 arc-second (red), and 8/15 arc-second (green) DEMs are also shown.

1.4.4 Comparison with National Geodetic Survey geodetic monuments

The locations of 5943 geodetic monuments were extracted from the NOAA NGS web site (http://www.ngs.noaa.gov/) in shapefile format (see Fig. 27 for monument locations). Only 202 monuments had defined elevations for use in the analysis. Shapefile attributes give positions in NAD 83 geographic horizontal datum (typically sub-mm accuracy). Elevations were given relative to the NAVD 88 Geoid 09 (meters) or NAD 83 ellipsoid. Conversions from the NAD 83 ellipsoid to NAVD 88 were performed using *VDatum*. Elevations were compared to the 8 arc-second Southeast Alaska DEM (Fig. 28). Differences between the DEM and the monument elevations range from -112.17 to 25.07 meters, with half of the differences between -8.36 and +4.72. Large differences in elevations occurred where monuments are located on road cuts, in regions of steep topography, on top of buildings or other structures, or have conversion errors evident on the NGS data sheet (e.g., feet instead of meters). In addition, the topographic data used in the Southeast Alaska DEM are not bare-earth, which contributes to large differences, particularly in forested regions.

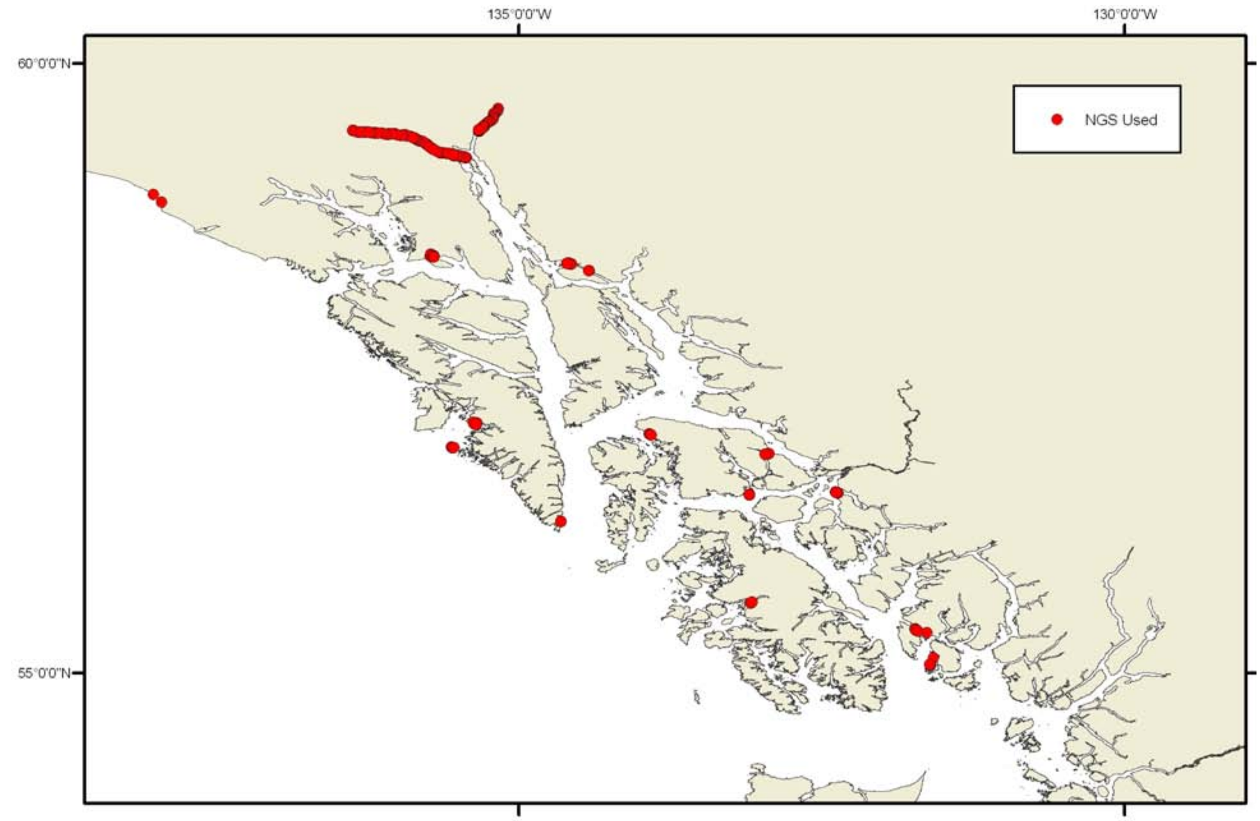

Figure 27. Location of NGS geodetic monuments in the Southeast Alaska region. The locations of the 202 sites used in the analysis are shown.

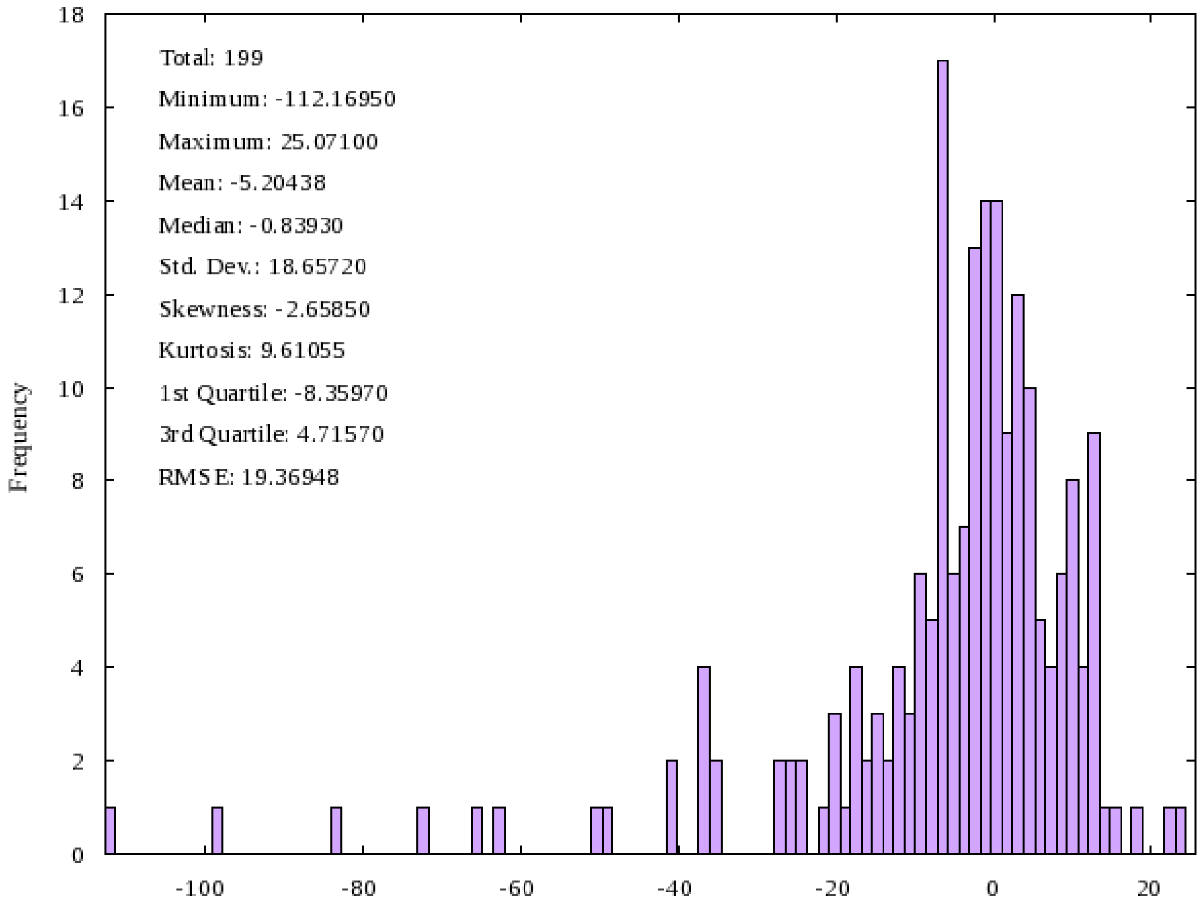

Figure 28. Histogram of the differences between NGS geodetic monument elevations and the 8 arc-second Southeast Alaska DEM.

1.4.5 Comparison with a prior NGDC DEM

As part of the Tsunami Inundation Gridding Project (TIGP; http://www.ngdc.noaa.gov/mgg/inundation/tsunami/inundation.html), NGDC developed a 1 arc-second DEM for the region surrounding Craig, AK (Lim et al., 2009). A quantitative comparison of the former DEM to the current DEM showed reasonable agreement between the two DEMs in most locations. Largest differences, on the order of tens to hundreds of meters, existed in the deep water, where the higher resolution data from the CHS replaced interpolated regions between trackline surveys in the TIGP Craig DEM. In addition, over 20 new surveys have been conducted since the development of the TIGP Craig DEM. These higher resolution surveys were used in the current Southeast Alaska grids and replaced older, lower resolution datasets that date from the early 1900s.

1.4.6 DEM comparison with source data files

To ensure grid accuracy, the 8/15 arc-second Juneau DEM was compared to source data files. A histogram of the differences between the SRTM and ASTER topographic DEMs and the 8/15 arc-second Juneau DEM are shown in Figures 29 and 30. Differences cluster around zero. The major differences in elevations in SRTM and ASTER data points with the grid (> 10 meters) are located in regions of steep slopes and forests, primarily along the coast.

Comparisons of the USACE hydrographic survey data and the 8/15 arc-second Juneau DEM are shown in Figure 31. Elevation differences range from -6.00460 to 5.43130 meters. Largest differences occur where the USACE data overlap other higher resolution datasets, which may occur due to changes in dredged depths or sediment deposition in channels.

The ENC soundings were also compared with the 8/15 arc-second Juneau DEM (Fig. 32). The histogram shows the differences in elevations range from -0.41620 to 8.16540 meters (Fig. 33). Similarly, differences between the NGDC trackline surveys and the 8/15 arc-second Juneau DEM are clustered around zero with differences ranging from -3.21 to 1.24 meters.

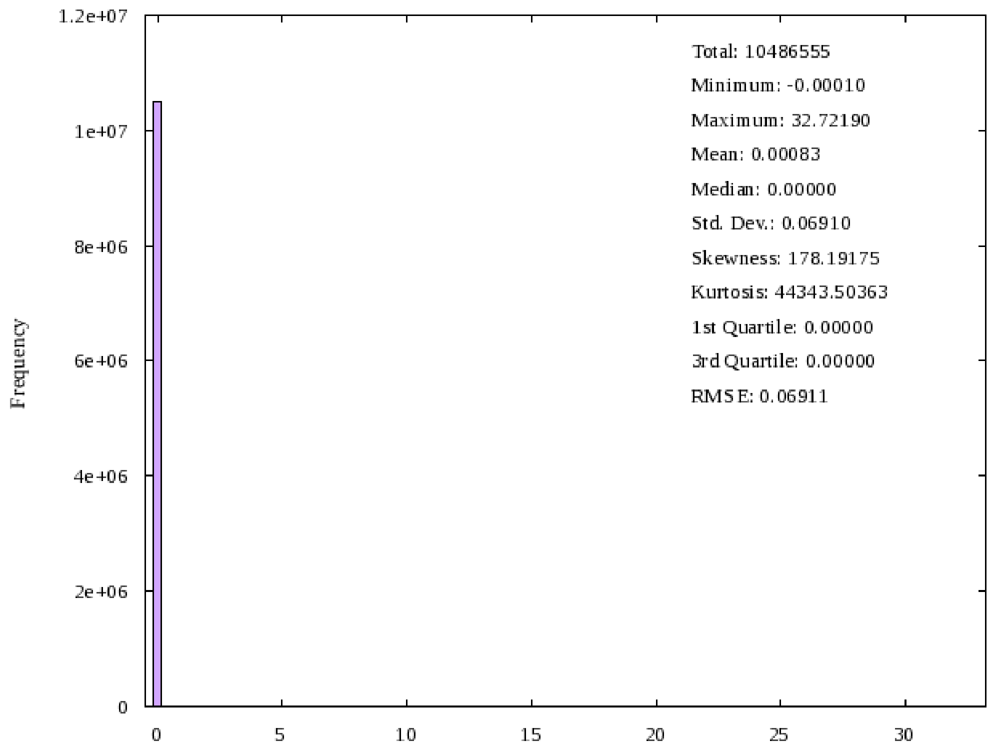

Figure 29. Histogram of the differences between the SRTM 1 arc-second topographic DEM data points and the 8/15 arc-second Juneau DEM.

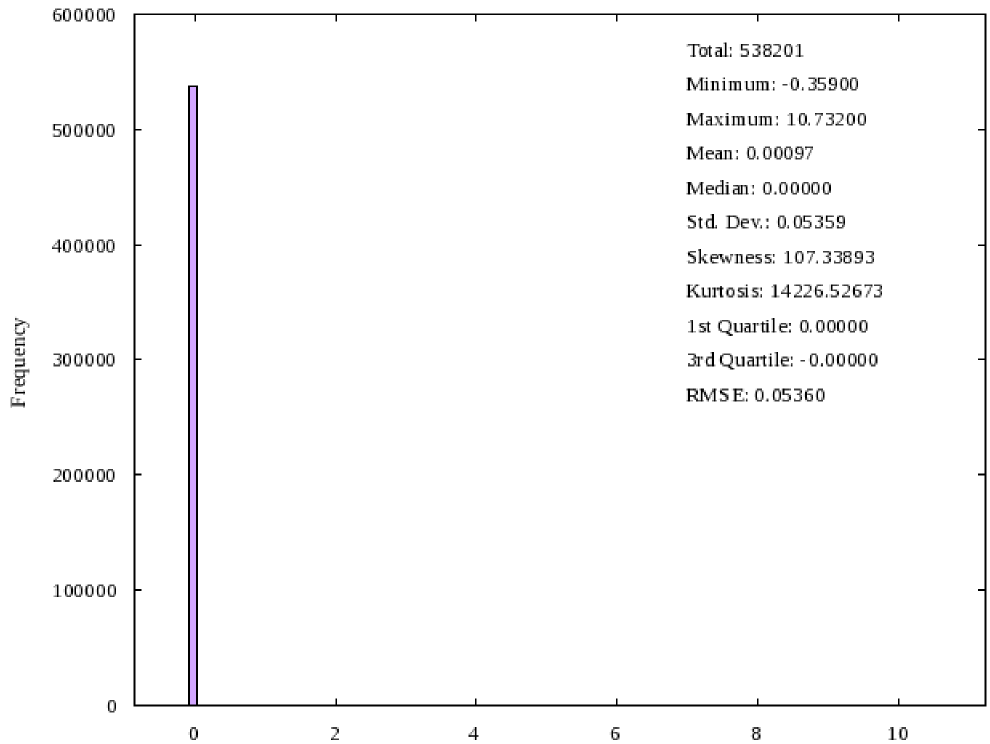

Figure 30. Histogram of the differences between the ASTER 1 arc-second DEM data points and the 8/15 arc-second Juneau DEM.

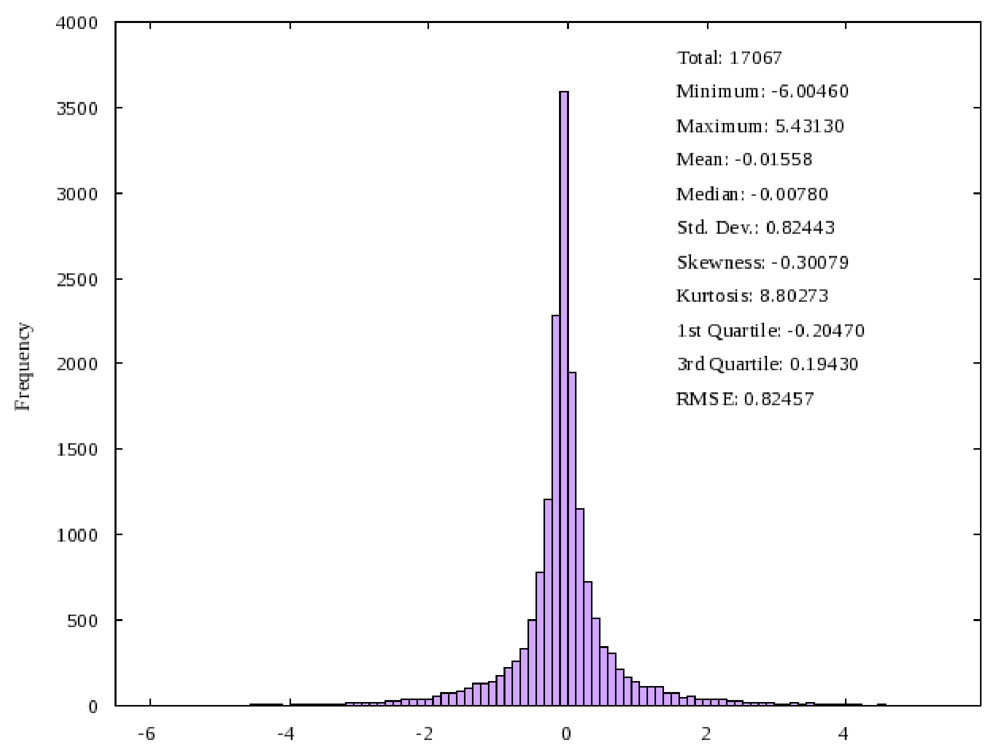

Figure 31. Histogram of the differences between the USACE hydrographic survey data points and the 8/15 arc-second Juneau DEM.

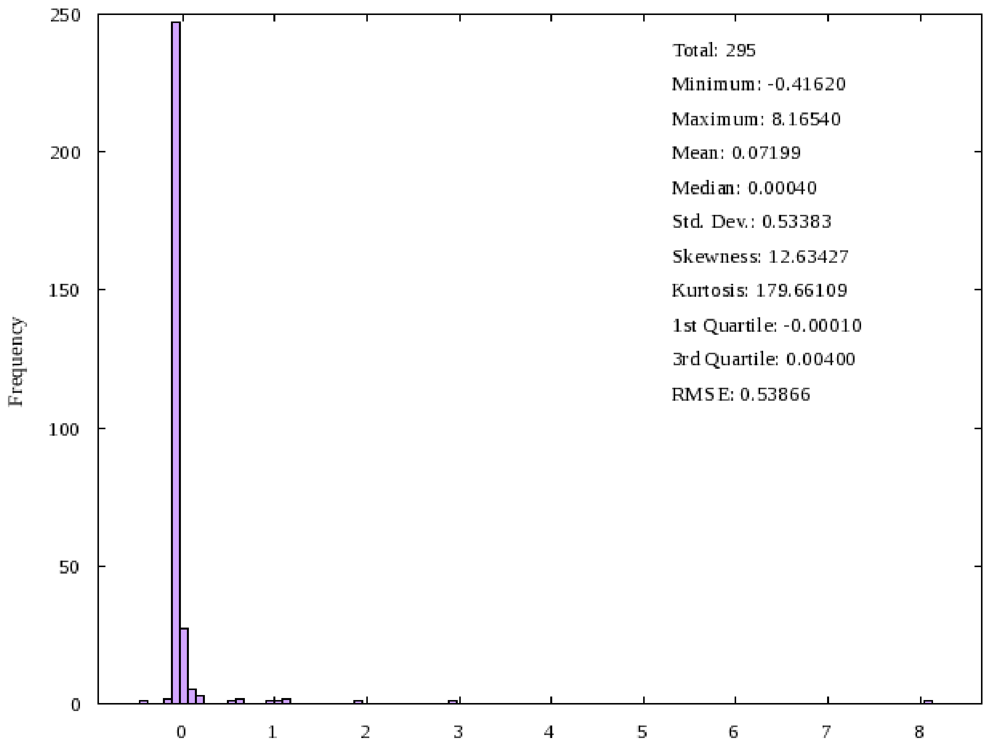

Figure 32. Histogram of the differences between the ENC sounding data points and the 8/15 arc-second Juneau DEM.

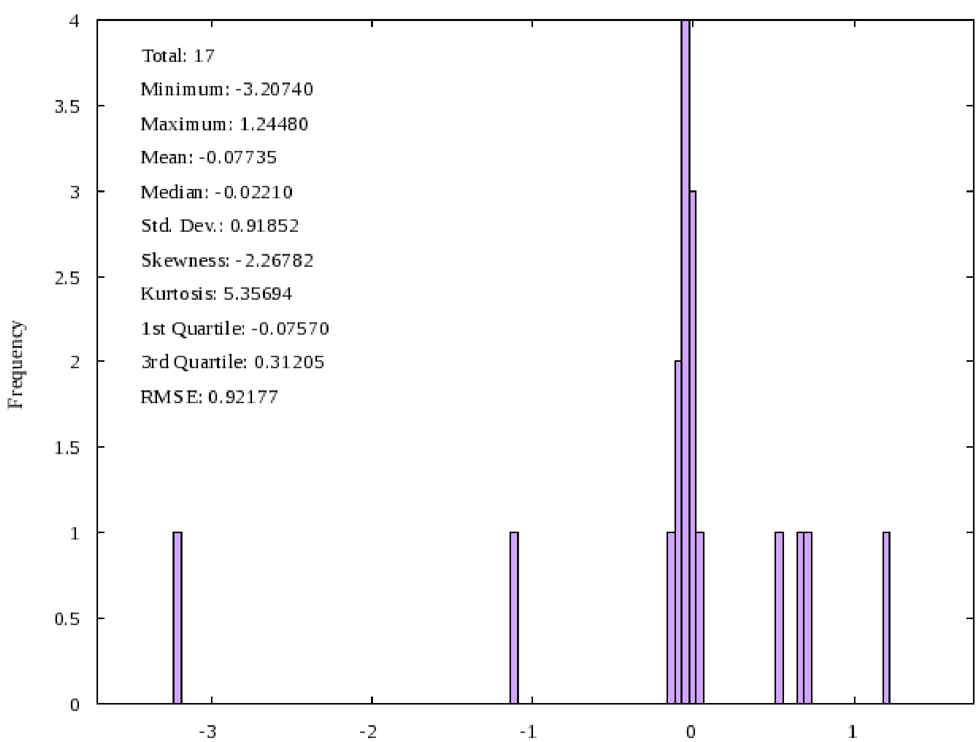

Figure 33. Histogram of the differences between the NGDC trackline data points and the 8/15 arc-second Juneau DEM.

4. Summary and Conclusions

Three nested, integrated bathymetric–topographic digital elevation models of the Southeast Alaska region, with cell sizes of 8/15, 8/3, and 8 arc-seconds, were developed for the National Tsunami Hazard Mitigation Program in support of the State of Alaska's tsunami inundation modeling efforts led by the Geophysical Institute at the University of Alaska at Fairbanks. The best available digital data from U.S. federal, state, local, and academic agencies were obtained by NGDC, shifted to common horizontal and vertical datums, and evaluated and edited before DEM generation. The data were quality checked, processed and gridded using ESRI *ArcGIS*, ESRI *ArcGIS World Imagery 2-D*, *FME*, *Fledermaus*, *GMT*, *MB-System*, *QT Modeler*, *GDAL, OGR, Proj4,* and *VDatum* software.

Recommendations to improve the Southeast Alaska DEMs, based on NGDC's research and analysis, are listed below:

- Conduct bathymetric surveys in the southwestern quarter of the 8 arc-second DEM region.
- Conduct a high-resolution topographic lidar surveys near the City of Juneau
- Establish, via survey, relationships between tidal and geodetic datums in the Southeast Alaska region.
- Determine the relationship between Early Alaska and NAD 83/WGS 84 geographic horizontal datums.

5. Acknowledgments

The creation of the Southeast Alaska DEMs was funded by the National Tsunami Hazard Mitigation Program. The authors thank Elena Sulemani, Dave West, and Dmitry Nikolski (UAF); Bret Christensen (USFWS); Hans Andersen and Mark Riley (U.S. Forest Service); John Stone and Gary Gillette (City of Juneau); and Denny Sinnott and Bodo de Lange Boom (CHS).

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Nautical Chart #501 (ENC and RNC), 13th Edition, 2009. North Pacific Ocean West Coast Of North America - Mexican Border To Dixon Entrance. Scale 1:3,500,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

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Nautical Chart #531 (ENC and RNC), 24th Edition, 2007. Gulf of Alaska - Strait of Juan de Fuca to Kodiak Island. Scale 1:2,100,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #16016 (ENC and RNC), 21st Edition, 2007. Dixon Entrance to Cape St. Elias. Scale 1:969,756. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #16760 (ENC and RNC), 10th Edition, 2000. Cross Sound to Yakutat Bay. Scale 1:300,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #16762 (RNC), 9th Edition, 2002. Lituya Bay - Lituya Bay Entrance. Scale 1:20,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17300 (ENC and RNC), 31st Edition, 2005. Stephens Passage to Cross Sound, including Lynn Canal. Scale 1:100,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17301 (ENC and RNC), 8th Edition, 1998. Cape Spencer to Icy Point. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17302 (ENC and RNC), 18th Edition, 2002. Icy Strait and Cross Sound; Inian Cove; Elfin Cove. Scale 1:80,000 with 1:20,000 and 1:10,000 insets. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17303 (RNC), 10th Edition, 2004. Yakobi Island and Lisianski Inlet; Pelican Harbor. Scale 1:40,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17311 (RNC), 1st Edition, 2000. Holkham Bay and Tracy Arm - Stephens Passage. Scale 1:40,000 with 1:20,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17312 (RNC), 2nd Edition, 2005. Hawk Inlet, Chatham Strait. Scale 1:10,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

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Nautical Chart #17315 (ENC and RNC), 24th Edition, 2006. Gastineau Channel and Taku Inlet; Juneau Harbor. Scale 1:40,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17316 (ENC and RNC), 20th Edition, 2002. Lynn Canal-Icy Strait to Point Sherman;Funter Bay; Chatham Strait. Scale 1:80,000 with 1:20,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17317 (RNC), 20th Edition, 2004. Lynn Canal-Point Sherman to Skagway; Lutak Inlet; Skagway and Nahku Bay; Portage Cove, Chilkoot Inlet. Scale 1:77,812 with 1:20,000 and 1:10,000 insets. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17318 (RNC), 1st Edition, 2009. Glacier Bay; Bartlett Cove. Scale 1:80,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17320 (ENC and RNC), 18th Edition, 2008. Coronation Island to Lisianski Strait. Scale 1:217,828. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17321 (RNC), 9th Edition, 2004. Cape Edward to Lisianski Strait, Chichagof Island. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17322 (RNC), 10th Edition, 2005. Khaz Bay, Chichagof Island Elbow Passage. Scale 1:40,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17323 (RNC), 12th Edition, 2006. Salisbury Sound, Peril Strait and Hoonah Sound. Scale 1:40,000 with 1:20,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17324 (RNC), 15th Edition, 2007. Sitka Sound to Salisbury Sound, Inside Passage; Neva Strait-Neva Point to Zeal Point. Scale 1:40,000 with 1:20,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17325 (RNC), 9th Edition, 2006. South and West Coasts of Kruzof Island. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17326 (ENC and RNC), 16th Edition, 2007. Crawfish Inlet to Sitka, Baranof Island; Sawmill Cove. Scale 1:40,000 with 1:5,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17327 (RNC), 23rd Edition, 2008. Sitka Harbor and approaches; Sitka Harbor. Scale 1:10,000 with 1:5,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17328 (ENC and RNC), 7th Edition, 2003. Snipe Bay to Crawfish Inlet, Baranof lsland. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17330 (RNC), 9th Edition, 2007. West Coast of Baranof Island - Cape Ommaney to Byron Bay. Scale 1:20,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17331 (RNC), 8th Edition, 2007. Chatham Strait - Ports Alexander, Conclusion, and Armstrong. Scale 1:10,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17333 (RNC), 9th Edition, 2007. Ports Herbert, Walter, Lucy and Armstrong. Scale 1:20,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17335 (RNC), 7th Edition, 2004. Patterson Bay and Deep Cove. Scale 1:20,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17336 (RNC), 9th Edition, 2007. Harbors in Chatham Strait and vicinity - Gut Bay, Chatham Strait; Hoggatt Bay, Chatham Strait; Red Bluff Bay, Chatham Strait; Herring Bay and Chapin Bay, Frederick Sound; Surprise Harbor, and Murder Cove, Frederick Sound. Scale 1:20,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17337 (RNC), 9th Edition, 2004. Harbors in Chatham Strait Kelp Bay;Warm Spring Bay; Takatz and Kasnyku Bays. Scale 1:40,000 with 1:20,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17338 (RNC), 14th Edition, 2005. Peril Strait - Hoonah Sound to Chatham Strait. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17339 (RNC), 12th Edition, 2007. Hood Bay and Kootznahoo Inlet. Scale 1:30,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17341 (RNC), 9th Edition, 2007. Whitewater Bay and Chaik Bay, Chatham Strait. Scale 1:20,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17360 (ENC and RNC), 35th Edition, 2008. Etolin Island to Midway Islands, including Sumner Strait; Holkham Bay; Big Castle Island. Scale 1:217,828 with 1:40,000 and 1:20,000 insets. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17362 (RNC), 10th Edition, 1996. Gambier Bay, Stephens Passage. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17363 (RNC), 13th Edition, 1997. Pybus Bay, Frederick Sound; Hobart and Windham Bays, Stephens Passage. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17365 (RNC), 12th Edition, 1997. Woewodski and Eliza Harbors.; Fanshaw Bay and Cleveland Passage. Scale 1:20,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17367 (RNC), 11th Edition, 1998. Thomas, Farragut, and Portage Bays, Frederick Sound. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17368 (ENC and RNC), 7th Edition, 2006. Keku Strait-northern part, including Saginaw and Security Bays and Port Camden; Kake Inset. Scale 1:40,000 with 1:15,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17370 (RNC), 11th Edition, 2006. Bay of Pillars and Rowan Bay, Chatham Strait; Washington Bay, Chatham Strait. Scale 1:20,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17372 (ENC and RNC), 11th Edition, 2003. Keku Strait-Monte Carlo Island to Entrance Island; The Summit; Devils Elbow. Scale 1:20,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17375 (ENC and RNC), 22nd Edition, 2009. Wrangell Narrows; Petersburg Harbor. Scale 1:20,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17376 (RNC), 8th Edition, 2008. Tebenkof Bay and Port Malmesbury. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17377 (RNC), 1st Edition, 1999. Le Conte Bay. Scale 1:25,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17378 (RNC), 14th Edition, 2004. Port Protection, Prince of Wales Island. Scale 1:20,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17379 (RNC), 1st Edition, 2002. Shakan Bay And Strait, Alaska. Scale 1:10,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17381 (RNC), 10th Edition, 2002. Red Bay, Prince of Wales Island. Scale 1:20,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17382 (ENC and RNC), 17th Edition, 2007. Zarembo Island and Approaches. Scale 1:80,000 with 1:40,000 and 1:20,000 insets. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17383 (RNC), 3rd Edition, 2005. Snow Passage, Alaska. Scale 1:30,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17384 (ENC and RNC), 9th Edition, 2008. Wrangell Harbor and approaches. Scale 1:20,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17385 (ENC and RNC), 17th Edition, 2009. Ernest Sound-Eastern Passage and Zimovia Strait; Zimovia Strait. Scale 1:80,000 with 1:20,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17386 (RNC), 4th Edition, 2006. Sumner Strait-Southern part. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17387 (RNC), 13th Edition, 2001. Shakan and Shipley Bays and Part of El Capitan Passage; El Capitan Passage, Dry Pass to Shakan Strait. Scale 1:40,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17400 (ENC and RNC), 17th Edition, 2007. Dixon Entrance to Chatham Strait. Scale 1:229,376. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17401 (RNC), 12th Edition, 2006. Lake Bay and approaches, Clarence Strait. Scale 1:10,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17402 (RNC), 11th Edition, 2005. Southern Entrances to Sumner Strait. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17403 (RNC), 14th Edition, 2006. Davidson Inlet and Sea Otter Sound; Edna Bay. Scale 1:40,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17404 (ENC and RNC), 14th Edition, 2008. San Christoval Channel to Cape Lynch. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17405 (ENC and RNC), 16th Edition, 2008. Ulloa Channel to San Christoval Channel; North Entrance, Big Salt Lake; Shelter Cove, Craig. Scale 1:40,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17406 (ENC and RNC), 7th Edition, 2004. Baker, Noyes, and Lulu Islands and adjacent waters. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17407 (RNC), 15th Edition, 2003. Northern part of Tlevak Strait and Uloa Channel. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17408 (RNC), 8th Edition, 2004. Central Dall Island and vicinity. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17409 (RNC), 10th Edition, 2002. Southern Dall Island and vicinity. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17420 (ENC and RNC), 28th Edition, 2007. Hecate Strait to Etolin Island, including Behm and Portland Canals. Scale 1:229,376. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17422 (RNC), 9th Edition, 2006. Behm Canal-western part; Yes Bay. Scale 1:79,334 with 1:40,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17423 (RNC), 14th Edition, 2006. Harbor Charts-Clarence Strait and Behm Canal Dewey Anchorage, Etolin Island; Ratz Harbor, Prince of Wales Island; Naha Bay, Revillagigedo Island; Tolstoi and Thorne Bays, Prince of Wales lsland; Union Bay, Cleveland Peninsula. Scale 1:40,000, 1:20,000, and 1:10,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17424 (ENC and RNC), 9th Edition, 2009. Behm Canal-eastern part. Scale 1:80,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17425 (ENC and RNC), 6th Edition, 2002. Portland Canal-North of Hattie Island. Scale 1:80,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17426 (RNC), 15th Edition, 2006. Kasaan Bay, Clarence Strait; Hollis Anchorage, eastern part; Lyman Anchorage. Scale 1:40,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17427 (RNC), 7th Edition, 1998. Portland Canal - Dixon Entrance to Hattie Island. Scale 1:80,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17428 (ENC and RNC), 10th Edition, 2007. Revillagigedo Channel, Nichols Passage, and Tongass Narrows; Seal Cove; Ward Cove. Scale 1:40,000 with 1:10,000 inset. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17430 (RNC), 11th Edition, 2005. Tongass Narrows. Scale 1:10,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17431 (RNC), 11th Edition, 2004. North End of Cordova Bay and Hetta Inlet. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17432 (RNC), 7th Edition, 2004. Clarence Strait and Moira Sound. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17433 (RNC), 11th Edition, 2004. Kendrick Bay to Shipwreck Point, Prince of Wales Island. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17434 (RNC), 13th Edition, 2005. Revillagigedo Channel; Ryus Bay; Foggy Bay. Scale 1:80,000 with 1:40,000 and 1:20,000 insets. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17435 (RNC), 16th Edition, 1999. Harbors in Clarence Strait Port Chester, Annette Island; Tamgas Harbor, Annette Island; Metlakatla Harbor. Scale 1:40,000 with 1:20,000 and 1:5,000 insets. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17436 (RNC), 9th Edition, 2006. Clarence Strait, Cholmondeley Sound and Skowl Arm. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Nautical Chart #17437 (RNC), 9th Edition, 2004. Portland Inlet to Nakat Bay. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

7. Data Processing Software

ArcGIS v. 9.3.1 – developed and licensed by ESRI, Redlands, California, http://www.esri.com/.

ESRI World Imagery (ESRI_Imagery_World_2D) – ESRI ArcGIS Resource Centers http://resources.esri.com/arcgisonlineservices/.

FME 2010 GB – Feature Manipulation Engine, developed and licensed by Safe Software, Vancouver, BC, Canada, http://www.safe.com/.

Fledermaus v. 7.0.0 – developed and licensed by Interactive Visualization Systems (IVS 3D), Fredericton, New Brunswick, Canada, http://www.ivs3d.com/products/fledermaus/.

GDAL v. 1.7.1 – Geographic Data Abstraction Library is a translator library maintained by Frank Warmerdam, http://www.gdal.org/.

GEODAS v. 5 – Geophysical Data System, freeware developed and maintained by Dan Metzger, NOAA National Geophysical Data Center, http://www.ngdc.noaa.gov/mgg/geodas/.

GMT v. 4.3.4 – Generic Mapping Tools, freeware developed and maintained by Paul Wessel and Walter Smith, funded by the National Science Foundation, http://gmt.soest.hawaii.edu/.

Gnuplot v. 4.2, free software developed and maintained by Thomas Williams, Colin Kelley, Russell Lang, Dave Kotz, John Campbell, Gershon Elber, Alexander Woo, http://www.gnuplot.info/.

MB-System v. 5.1.0 – shareware developed and maintained by David W. Caress and Dale N. Chayes, funded by the National Science Foundation, http://www.ldeo.columbia.edu/res/pi/MB-System/.

Proj4 v. 4.7.0, free software developed by Gerald Evenden and maintained by Frank Warmerdam, http://trac.osgeo/org/proj/.

Quick Terrain Modeler v. 7.0.0 – Lidar processing software developed by John Hopkins University's Applied Physics Laboratory (APL) and maintained and licensed by Applied Imagery, http://www.appliedimagery.com/

VDatum Transformation Tool, developed and maintained by NOAA's National Geodetic Survey (NGS), Office of Coast Survey (OCS), and Center for Operational Oceanographic Products and Services (CO-OPS), http://vdatum.noaa.gov/.

APPENDIX A. Electronic and Raster Nautical Charts Available in the Southeast Alaska Region

Chart	Title	Source Edition	Source Date	Format	Scale
50	North Pacific Ocean (eastern part) Bering Sea Continuation	6th	2003	ENC and RNC	1:10,000,000
500	West Coast Of North America - Dixon Entrance To Unimak Pass	8th	2003	ENC and RNC	1:3,500,000
501	North Pacific Ocean West Coast Of North America - Mexican Border To Dixon Entrance	13th	2009	ENC and RNC	1:3,500,000
530	North America West Coast - San Diego to Aleutian Islands and Hawaiian Islands	32nd	2007	ENC and RNC	1:4,860,700
531	Gulf of Alaska - Strait of Juan de Fuca to Kodiak Island	24th	2007	ENC and RNC	1:2,100,000
16016	Dixon Entrance to Cape St. Elias	21st	2007	ENC and RNC	1:969,756
16760	Cross Sound to Yakutat Bay	10th	2000	ENC and RNC	1:300,000
16762	Lituya Bay - Lituya Bay Entrance	9th	2002	RNC	1:20,000 with 1:10,000 inset
17300	Stephens Passage to Cross Sound, including Lynn Canal	31st	2005	ENC and RNC	1:100,000
17301	Cape Spencer to Icy Point	8th	1998	ENC and RNC	1:40,000
17302	Icy Strait and Cross Sound; Inian Cove; Elfin Cove	18th	2002	ENC and RNC	1:80,000 with 1:20,000 and 1:10,000 insets
17303	Yakobi Island and Lisianski Inlet; Pelican Harbor	10th	2004	RNC	1:40,000 with 1:10,000 inset
17311	Holkham Bay and Tracy Arm - Stephens Passage	1st	2000	RNC	1:40,000 with 1:20,000 inset
17312	Hawk Inlet, Chatham Strait	2nd	2005	RNC	1:10,000
17313	Port Snettisham	9th	2009	RNC	1:40,000
17314	Slocum and Limestone Inlets and Taku Harbor	12th	1998	RNC	1:20,000
17315	Gastineau Channel and Taku Inlet; Juneau Harbor	24th	2006	ENC and RNC	1:40,000 with 1:10,000 inset
17316	Lynn Canal-Icy Strait to Point Sherman;Funter Bay; Chatham Strait	20th	2002	ENC and RNC	1:80,000 with 1:20,000 inset
17317	Lynn Canal-Point Sherman to Skagway; Lutak Inlet; Skagway and Nahku Bay; Portage Cove, Chilkoot Inlet	20th	2004	RNC	1:77,812 with 1:20,000 and 1:10,000 insets
17318	Glacier Bay; Bartlett Cove	1st	2009	RNC	1:80,000 with 1:10,000 inset
17320	Coronation Island to Lisianski Strait	18th	2008	ENC and RNC	1:217,828
17321	Cape Edward to Lisianski Strait, Chichagof Island	9th	2004	RNC	1:40,000
17322	Khaz Bay, Chichagof Island Elbow Passage	10th	2005	RNC	1:40,000 with 1:10,000 inset
17323	Salisbury Sound, Peril Strait and Hoonah Sound	12th	2006	RNC	1:40,000 with 1:20,000 inset
17324	Sitka Sound to Salisbury Sound, Inside Passage; Neva Strait-Neva Point to Zeal Point	15th	2007	RNC	1:40,000 with 1:20,000 inset
17325	South and West Coasts of Kruzof Island	9th	2006	RNC	1:40,000
17326	Crawfish Inlet to Sitka, Baranof Island; Sawmill Cove	16th	2007	ENC and RNC	1:40,000 with 1:5,000 inset
17327	Sitka Harbor and approaches; Sitka Harbor	23rd	2008	RNC	1:10,000 with 1:5,000 inset
17328	Snipe Bay to Crawfish Inlet, Baranof lsland	7th	2003	ENC and RNC	1:40,000
17330	West Coast of Baranof Island - Cape Ommaney to Byron Bay	9th	2007	RNC	1:20,000
17331	Chatham Strait - Ports Alexander, Conclusion, and Armstrong	8th	2007	RNC	1:10,000

17333	Ports Herbert, Walter, Lucy and Armstrong	9th	2007	RNC	1:20,000
17335	Patterson Bay and Deep Cove	7th	2004	RNC	1:20,000
17336	Harbors in Chatham Strait and vicinity - Gut Bay, Chatham Strait; Hoggatt Bay, Chatham Strait	9th	2007	RNC	1:20,000
17337	Harbors in Chatham Strait Kelp Bay;Warm Spring Bay; Takatz and Kasnyku Bays	9th	2004	RNC	1:40,000 with 1:20,000 inset
17338	Peril Strait - Hoonah Sound to Chatham Strait	14th	2005	RNC	1:40,000
17339	Hood Bay and Kootznahoo Inlet	12th	2007	RNC	1:30,000 with 1:10,000 inset
17341	Whitewater Bay and Chaik Bay, Chatham Strait	9th	2007	RNC	1:20,000
17360	Etolin Island to Midway Islands, including Sumner Strait; Holkham Bay; Big Castle Island	35th	2008	ENC and RNC	1:217,828 with 1:40,000 and 1:20,000 insets
17362	Gambier Bay, Stephens Passage	10th	1996	RNC	1:40,000
17363	Pybus Bay, Frederick Sound; Hobart and Windham Bays, Stephens Passage	13th	1997	RNC	1:40,000
17365	Woewodski and Eliza Harbors.; Fanshaw Bay and Cleve-land Passage	12th	1997	RNC	1:20,000
17367	Thomas, Farragut, and Portage Bays, Frederick Sound	11th	1998	RNC	1:40,000
17368	Keku Strait-northern part, including Saginaw and Security Bays and Port Camden; Kake Inset	7th	2006	ENC and RNC	1:40,000 with 1:15,000 inset
17370	Bay of Pillars and Rowan Bay, Chatham Strait; Washington Bay, Chatham Strait	11th	2006	RNC	1:20,000 with 1:10,000 inset
17372	Keku Strait-Monte Carlo Island to Entrance Island; The Summit; Devils Elbow	11th	2003	ENC and RNC	1:20,000 with 1:10,000 inset
17375	Wrangell Narrows; Petersburg Harbor	22nd	2009	ENC and RNC	1:20,000 with 1:10,000 inset
17376	Tebenkof Bay and Port Malmesbury	8th	2008	RNC	1:40,000
17377	Le Conte Bay	1st	1999	RNC	1:25,000
17378	Port Protection, Prince of Wales Island	14th	2004	RNC	1:20,000
17379	Shakan Bay And Strait, Alaska	1st	2002	RNC	1:10,000
17381	Red Bay, Prince of Wales Island	10th	2002	RNC	1:20,000
17382	Zarembo Island and Approaches	17th	2007	ENC and RNC	1:80,000 with 1:40,000 and 1:20,000 insets
17383	Snow Passage, Alaska	3rd	2005	RNC	1:30,000
17384	Wrangell Harbor and approaches	9th	2008	ENC and RNC	1:20,000 with 1:10,000 inset
17385	Ernest Sound-Eastern Passage and Zimovia Strait; Zimovia Strait	17th	2009	ENC and RNC	1:80,000 with 1:20,000 inset
17386	Sumner Strait-Southern part	4th	2006	RNC	1:40,000
17387	Shakan and Shipley Bays and Part of El Capitan Passage; El Capitan Passage, Dry Pass to Shakan Strait	13th	2001	RNC	1:40,000 with 1:10,000 inset
17400	Dixon Entrance to Chatham Strait	17th	2007	ENC and RNC	1:229,376
17401	Lake Bay and approaches, Clarence Strait	12th	2006	RNC	1:10,000
17402	Southern Entrances to Sumner Strait	11th	2005	RNC	1:40,000
17403	Davidson Inlet and Sea Otter Sound; Edna Bay	14th	2006	RNC	1:40,000 with 1:10,000 inset
17404	San Christoval Channel to Cape Lynch	14th	2008	ENC and RNC	1:40,000
17405	Ulloa Channel to San Christoval Channel; North Entrance, Big Salt Lake; Shelter Cove, Craig	16th	2008	ENC and RNC	1:40,000 with 1:10,000 inset
17406	Baker, Noyes, and Lulu Islands and adjacent waters	7th	2004	ENC and RNC	1:40,000
17407	Northern part of Tlevak Strait and Uloa Channel	15th	2003	RNC	1:40,000

17408	Central Dall Island and vicinity	8th	2004	RNC	1:40,000
17409	Southern Dall Island and vicinity	10th	2002	RNC	1:40,000
17420	Hecate Strait to Etolin Island, including Behm and Portland Canals	28th	2007	ENC and RNC	1:229,376
17422	Behm Canal-western part; Yes Bay	9th	2006	RNC	1:79,334 with 1:40,000 inset
17423	Harbor Charts-Clarence Strait and Behm Canal Dewey Anchorage, Etolin Island; Ratz Harbor	14th	2006	RNC	1:40,000 with 1:20,000 and 1:10,000 insets
17424	Behm Canal-eastern part	9th	2009	ENC and RNC	1:80,000
17425	Portland Canal-North of Hattie Island	6th	2002	ENC and RNC	1:80,000
17426	Kasaan Bay, Clarence Strait; Hollis Anchorage, eastern part; Lyman Anchorage	15th	2006	RNC	1:40,000 with 1:10,000 inset
17427	Portland Canal - Dixon Entrance to Hattie Island	7th	1998	RNC	1:80,000
17428	Revillagigedo Channel, Nichols Passage, and Tongass Narrows; Seal Cove; Ward Cove	10th	2007	ENC and RNC	1:40,000 with 1:10,000 inset
17430	Tongass Narrows	11th	2005	RNC	1:10,000
17431	North End of Cordova Bay and Hetta Inlet	11th	2004	RNC	1:40,000
17432	Clarence Strait and Moira Sound	7th	2004	RNC	1:40,000
17433	Kendrick Bay to Shipwreck Point, Prince of Wales Island	11th	2004	RNC	1:40,000
17434	Revillagigedo Channel; Ryus Bay; Foggy Bay	13th	2005	RNC	1:80,000 with 1:40,000 and 1:20,000 insets
17435	Harbors in Clarence Strait Port Chester, Annette Island; Tamgas Harbor, Annette Island; Metlakatla Harbor	16th	1999	RNC	1:40,000 with 1:20,000 and 1:5,000 insets
17436	Clarence Strait, Cholmondeley Sound and Skowl Arm	9th	2006	RNC	1:40,000
17437	Portland Inlet to Nakat Bay	9th	2004	RNC	1:40,000

Appendix B. NOS Hydrographic Surveys used in Compiling the Southeast Alaska DEMs

Survey ID	*Year*	*Scale or Resolution*	*Original Horizontal Datum*	*Original Vertical Datum*
H01618A	1883	80,000	Undetermined	MLLW
H01891	1888	80,000	Undetermined	MLLW
H01996	1889	80,000	Early Alaska Datum	MLLW
H02142	1892	80,000	Undetermined	MLLW
H02241	1895	10,000	Undetermined	MLLW
H02333	1897	80,000	Early Alaska Datum	MLW
H02558	1901	40,000	Undetermined	MLLW
H02665	1903	600,000	Undetermined	MLLW
H02857	1906	10,000	Undetermined	MLLW
H02858	1906	20,000	Undetermined	MLLW
H02859	1906	10,000	Undetermined	MLLW
H03042	1909	20,000	Undetermined	MLLW
H03042A	1909	40,000	Undetermined	MLLW
H03390	1912	20,000	Undetermined	MLLW
H03416	1912	20,000	Undetermined	MLLW
H03417	1912	20,000	Undetermined	MLLW
H03427	1912	10,000	Undetermined	MLLW
H03427I	1912	20,000	Undetermined	MLLW
H03539	1913	10,000	Undetermined	MLLW
H03540	1913	20,000	Undetermined	MLLW
H03547	1913	10,000	Undetermined	MLLW
H03666	1914	10,000	Undetermined	MLLW
H03678	1914	20,000	Undetermined	MLLW
H03679	1914	10,000	Undetermined	MLLW
H03680	1914	10,000	Undetermined	MLW
H03691	1914	20,000	Undetermined	MLLW
H03692	1914	20,000	Undetermined	MLLW
H03692A	1914	20,000	Undetermined	MLLW
H03710	1914	10,000	Early Alaska Datum	MLLW
H03781	1915	20,000	Undetermined	MLLW
H03787	1915	40,000	Undetermined	MLLW
H03789	1915	40,000	Undetermined	MLLW
H03795	1915	10,000	Undetermined	MLLW
H03818	1915	20,000	Undetermined	MLLW
H03880	1915	20,000	Undetermined	MLLW
H03819A	1916	120,000	Undetermined	MLLW
H03912	1916	20,000	Undetermined	MLLW
H03930	1916	10,000	Undetermined	MLLW
H03931	1916	40,000	Undetermined	MLLW
H03932	1916	20,000	Undetermined	MLLW
H03932I	1916	10,000	Undetermined	MLLW
H03933	1916	20,000	Undetermined	MLLW
H03940	1916	20,000	Undetermined	MLLW
H03932A	1917	20,000	Undetermined	MLLW
H04002	1917	20,000	Undetermined	MLLW

Survey ID	Year	Scale or Resolution	Original Horizontal Datum	Original Vertical Datum
H04009	1917	20,000	Undetermined	MLLW
H03819B	1920	120,000	Undetermined	MLLW
H04158	1920	50,000	Undetermined	MLLW
H04160	1920	20,000	Undetermined	MLLW
H04161	1920	20,000	Undetermined	MLLW
H04191	1920	20,000	Undetermined	MLLW
H04192	1920	20,000	Undetermined	MLLW
H04188	1921	80,000	Undetermined	MLLW
H04200	1921	20,000	Undetermined	MLLW
H04203	1921	20,000	Undetermined	MLLW
H04204	1921	10,000	Undetermined	MLLW
H04208A	1921	120,000	Undetermined	MLLW
H04208B	1921	60,000	Undetermined	MLLW
H04209I1	1921	10,000	Undetermined	MLLW
H04209	1921	20,000	Undetermined	MLLW
H04209I2	1921	10,000	Undetermined	MLLW
H04251	1922	20,000	Undetermined	MLLW
H04252	1922	20,000	Undetermined	MLLW
H04254	1922	10,000	Undetermined	MLLW
H04259	1922	20,000	Undetermined	MLLW
H04260	1922	20,000	Undetermined	MLLW
H04261A	1922	120,000	Undetermined	MLLW
H04261B	1922	60,000	Undetermined	MLLW
H04264	1922	20,000	Undetermined	MLLW
H04271	1922	20,000	Undetermined	MLLW
H04272	1922	20,000	Undetermined	MLLW
H04273	1922	20,000	Undetermined	MLLW
H04274	1922	50,000	Undetermined	MLLW
H04325	1923	20,000	Undetermined	MLLW
H04326	1923	20,000	Undetermined	MLLW
H04330	1923	10,000	Undetermined	MLLW
H04331	1923	30,000	Undetermined	MLLW
H04392B	1924	2000	Undetermined	MLLW
H04431	1924	20,000	Undetermined	MLLW
H04432	1924	80,000	Undetermined	MLLW
H04441	1924	10,000	Undetermined	MLLW
H04443A	1924	20,000	Undetermined	MLLW
H04514A	1925	20,000	Undetermined	MLLW
H04515	1925	20,000	Undetermined	MLLW
H04516	1925	40,000	Undetermined	MLLW
H04517A	1925	20,000	Undetermined	MLLW
H04524	1925	20,000	Undetermined	MLLW
H04525A	1925	10,000	Undetermined	MLLW
H04526	1925	10,000	Undetermined	MLLW
H04527	1925	10,000	Undetermined	MLLW
H04528	1925	80,000	Undetermined	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
H04529	1925	100000	Undetermined	MLLW
H04530	1925	20,000	Undetermined	MLLW
H04534	1925	10,000	Undetermined	MLLW
H04535	1925	20,000	Undetermined	MLLW
H04536	1925	40,000	Undetermined	MLLW
H04539	1925	20,000	Undetermined	MLLW
H04594	1926	20,000	Undetermined	MLLW
H04601	1926	10,000	Undetermined	MLLW
H04602	1926	20,000	Undetermined	MLLW
H04603	1926	20,000	Undetermined	MLLW
H04608	1926	20,000	Southeast Alaska Datum	MLLW
H04622A	1926	20,000	Undetermined	MLLW
H04623A	1926	20,000	Undetermined	MLLW
H04624	1926	20,000	Undetermined	MLLW
H04625	1926	20,000	Undetermined	MLLW
H04626A	1926	40,000	Undetermined	MLLW
H04626AI	1926	20,000	Undetermined	MLLW
H04627	1926	10,000	Undetermined	MLLW
H04640	1926	20,000	Undetermined	MLLW
H04641	1926	20,000	Undetermined	MLLW
H04648	1926	100000	Undetermined	MLLW
H04761A	1927	10,000	Undetermined	MLLW
H04773	1927	10,000	Undetermined	MLLW
H04774	1927	10,000	Undetermined	MLLW
H04842	1928	20,000	Undetermined	MLLW
H04843	1928	20,000	NAD 27 geographic	MLLW
H04846	1928	20,000	NAD 27 geographic	MLLW
H04847	1928	20,000	Undetermined	MLLW
H05060	1930	20,000	Early Alaska Datum	MLLW
H05061	1930	10,000	Early Alaska Datum	MLLW
H05079	1930	20,000	Early Alaska Datum	MLLW
H05102	1930	10000	Early Alaska Datum	MLLW
H05103	1930	20,000	Early Alaska Datum	MLLW
H05105	1930	20,000	Early Alaska Datum	MLLW
H05106	1930	20,000	Early Alaska Datum	MLLW
H05137	1931	5,000	Early Alaska Datum	MLLW
H05144	1931	20,000	Early Alaska Datum	MLLW
H05145	1931	20,000	Early Alaska Datum	MLLW
H05150	1931	20,000	Early Alaska Datum	MLLW
H05174	1931	20,000	Early Alaska Datum	MLLW
H05175	1931	20,000	Early Alaska Datum	MLLW
H05176	1931	20,000	Early Alaska Datum	MLLW
H05185	1931	20,000	Early Alaska Datum	MLLW
H05205	1932	20,000	Early Alaska Datum	MLLW
H05236	1932	20,000	Early Alaska Datum	MLLW
H05243	1932	10000	Early Alaska Datum	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
H05244	1932	20,000	Early Alaska Datum	MLLW
H05263	1932	40000	Early Alaska Datum	MLLW
H05268	1932	40000	Early Alaska Datum	MLLW
H05267	1933	20,000	Early Alaska Datum	MLLW
H05281	1933	20,000	Early Alaska Datum	MLLW
H05360	1933	10000	Early Alaska Datum	MLLW
H05372	1933	10000	Early Alaska Datum	MLLW
H05384	1933	10000	Early Alaska Datum	MLLW
H05385	1933	10000	Early Alaska Datum	MLLW
H05386	1933	20000	Early Alaska Datum	MLLW
H05387	1933	20000	Early Alaska Datum	MLLW
H05388	1933	20000	Early Alaska Datum	MLLW
H05389	1933	20000	Early Alaska Datum	MLLW
H06177	1936	10,000/5,000	Early Alaska Datum	MLLW
H06267	1937	10,000	Early Alaska Datum	MLLW
H06268	1937	10,000	Early Alaska Datum	MLLW
H06269	1937	10,000	Early Alaska Datum	MLLW
H06273	1937	20,000	Early Alaska Datum	MLLW
H06275	1937	10,000	Early Alaska Datum	MLLW
H06276	1937	10,000	Early Alaska Datum	MLLW
H06282	1937	5,000	Early Alaska Datum	MLLW
H06283	1937	20,000	Early Alaska Datum	MLLW
H06284	1937	20,000	Early Alaska Datum	MLLW
H06285	1937	20,000	Early Alaska Datum	MLLW
H06336	1938	5,000	Early Alaska Datum	MLLW
H06337	1938	10,000	Early Alaska Datum	MLLW
H06338	1938	10,000	Early Alaska Datum	MLLW
H06339	1938	20,000	Early Alaska Datum	MLLW
H06340	1938	20,000	Early Alaska Datum	MLLW
H06351	1938	1,000	Early Alaska Datum	MLLW
H06352	1938	5,000	Early Alaska Datum	MLLW
H06353	1938	5,000	Early Alaska Datum	MLLW
H06354	1938	10,000	Early Alaska Datum	MLLW
H06355	1938	10,000	Early Alaska Datum	MLLW
H06358	1938	10,000	Early Alaska Datum	MLLW
H06457	1939	20,000	Early Alaska Datum	MLLW
H06459	1939	10,000	Early Alaska Datum	MLLW
H06458	1940	20,000	Early Alaska Datum	MLLW
H06574	1940	10,000	Early Alaska Datum	MLLW
H06575	1940	20,000	Early Alaska Datum	MLLW
H06576	1940	20,000	Early Alaska Datum	MLLW
H06578	1940	40,000	Early Alaska Datum	MLLW
H06579	1940	200,000	Early Alaska Datum	MLLW
H06580	1940	40,000	Early Alaska Datum	MLLW
H06581	1940	100,000	Early Alaska Datum	MLLW
H06582	1940	20,000	Early Alaska Datum	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
H06583	1940	20,000	Early Alaska Datum	MLLW
H06584	1940	20,000	Early Alaska Datum	MLLW
H06585	1940	20,000	Early Alaska Datum	MLLW
H06655	1941	20,000	Early Alaska Datum	MLLW
H06666	1941	10,000	Early Alaska Datum	MLLW
H06667	1941	20,000	Early Alaska Datum	MLLW
H06743	1941	40,000	Early Alaska Datum	MLLW
H06764	1942	5,000	Early Alaska Datum	MLLW
H06765	1942	5,000	Early Alaska Datum	MLLW
H06766	1942	5,000	Early Alaska Datum	MLLW
H06795	1942	1,000	Early Alaska Datum	MLLW
H06855	1943	5,000	Early Alaska Datum	MLLW
H06856	1943	5,000	Early Alaska Datum	MLLW
H06942	1943	5,000	Early Alaska Datum	MLLW
H06944	1943	10,000	Early Alaska Datum	MLLW
H06945	1943	2,000	Early Alaska Datum	MLLW
H06946	1943	5,000	Early Alaska Datum	MLLW
H06947	1943	10,000	Early Alaska Datum	MLLW
H06948	1943	10,000	Early Alaska Datum	MLLW
H07096	1945	10,000	Early Alaska Datum	MLLW
H07097	1945	5,000	Early Alaska Datum	MLLW
H07163	1945	1,200	Early Alaska Datum	MLLW
H08230	1945	10,000	Early Alaska Datum	MLLW
H07095	1946	2,500	Early Alaska Datum	MLLW
H07098	1946	5,000	Early Alaska Datum	MLLW
H07189	1947	10,000	Early Alaska Datum	MLLW
H07190	1947	10,000	Early Alaska Datum	MLLW
H07191	1947	10,000	Early Alaska Datum	MLLW
H07193	1947	10,000	Early Alaska Datum	MLLW
H07674	1948	5,000	Early Alaska Datum	MLLW
H07675	1948	5,000	Early Alaska Datum	MLLW
H07676	1948	10,000	Early Alaska Datum	MLLW
H07787	1949	10,000	Early Alaska Datum	MLLW
H07788	1949	10,000	NAD 27 geographic	MLLW
H07789	1949	10,000	Early Alaska Datum	MLLW
H07638	1950	5,000	Early Alaska Datum	MLLW
H07860	1950	10,000	Early Alaska Datum	MLLW
H07861	1950	10,000	Early Alaska Datum	MLLW
H07869	1951	5,000	Early Alaska Datum	MLLW
H07930	1951	5,000	Early Alaska Datum	MLLW
H07931	1951	10,000	Early Alaska Datum	MLLW
H07673	1952	5,000	Early Alaska Datum	MLLW
H07961	1952	5,000	Early Alaska Datum	MLLW
H07985	1952	5,000	Early Alaska Datum	MLLW
H07986	1952	10,000	Early Alaska Datum	MLLW
H07988	1952	10,000	Early Alaska Datum	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
H07989	1952	10,000	Early Alaska Datum	MLLW
H08032	1952	10,000	Early Alaska Datum	MLLW
H08033	1952	10,000	Early Alaska Datum	MLLW
H08036	1953	10,000	Early Alaska Datum	MLLW
H08037	1953	10,000	Early Alaska Datum	MLLW
H08038	1953	10,000	Early Alaska Datum	MLLW
H08064	1953	20,000	Early Alaska Datum	MLLW
H08065A	1953	10,000	NAD 27 geographic	MLLW
H08065B	1953	10,000	NAD 27 geographic	MLLW
H08067	1953	10,000	Early Alaska Datum	MLLW
H08125	1954	10,000	Early Alaska Datum	MLLW
H08126	1954	10,000	Early Alaska Datum	MLLW
H08127	1954	10,000	Early Alaska Datum	MLLW
H08128	1954	10,000	Early Alaska Datum	MLLW
H08129	1954	10,000	Early Alaska Datum	MLLW
H08130	1954	10,000	Early Alaska Datum	MLLW
H08131	1954	10,000	Early Alaska Datum	MLLW
H08132	1954	10,000	Early Alaska Datum	MLLW
H08133	1954	10,000	Early Alaska Datum	MLLW
H08134	1954	20,000	Early Alaska Datum	MLLW
H08148	1954	20,000	Early Alaska Datum	MLLW
H08149	1954	10,000	Early Alaska Datum	MLLW
H08150	1954	10,000	Early Alaska Datum	MLLW
H08151	1955	10,000	Early Alaska Datum	MLLW
H08229	1955	10,000	Early Alaska Datum	MLLW
H08231	1955	10,000	Early Alaska Datum	MLLW
H08232	1955	10,000	Early Alaska Datum	MLLW
H08244	1955	10,000	Early Alaska Datum	MLLW
H08245	1955	10,000	Early Alaska Datum	MLLW
H08325	1955	10,000	NAD 27 geographic	MLLW
H08286	1956	10,000	Early Alaska Datum	MLLW
H08287	1956	10,000	Early Alaska Datum	MLLW
H08288	1956	10,000	Early Alaska Datum	MLLW
H08289	1956	10,000	Early Alaska Datum	MLLW
H08290	1956	10,000	Early Alaska Datum	MLLW
H08326	1956	5,000	Early Alaska Datum	MLLW
H07987	1957	10,000	Early Alaska Datum	MLLW
H08359	1957	10,000	Early Alaska Datum	MLLW
H08382	1957	20,000	Early Alaska Datum	MLLW
H08383	1957	10,000	Early Alaska Datum	MLLW
H08384	1957	10,000	Early Alaska Datum	MLLW
H08385	1957	10,000	Early Alaska Datum	MLLW
H08391	1957	10,000	Early Alaska Datum	MLLW
H08392	1957	10,000	Early Alaska Datum	MLLW
H08393	1957	10,000	NAD 27 geographic	MLLW
H08440	1958	10,000	Early Alaska Datum	MLLW

Survey ID	*Year*	*Scale or Resolution*	*Original Horizontal Datum*	*Original Vertical Datum*
H08441	1958	10,000	Early Alaska Datum	MLLW
H08442	1958	20,000	Early Alaska Datum	MLLW
H08443	1958	10,000	Early Alaska Datum	MLLW
H08444	1958	40,000	NAD 27 geographic	MLLW
H08455	1958	10,000	NAD 27 geographic	MLLW
H08456	1958	10,000	NAD 27 geographic	MLLW
H08457	1958	10,000	NAD 27 geographic	MLLW
H08458	1958	10,000	Early Alaska Datum	MLLW
H08466	1959	10,000	Early Alaska Datum	MLLW
H08467	1959	10,000	Early Alaska Datum	MLLW
H08492	1959	10,000	Early Alaska Datum	MLLW
H08501	1959	1,000	Early Alaska Datum	MLLW
H08112	1960	20,000	NAD 27 geographic	MLLW
H08517	1960	5,000	Early Alaska Datum	MLLW
H08531	1960	10,000	Early Alaska Datum	MLLW
H08532	1960	10,000	Early Alaska Datum	MLLW
H08545	1960	10,000	Early Alaska Datum	MLLW
H08546	1960	10,000	Early Alaska Datum	MLLW
H08604	1961	20,000	Early Alaska Datum	MLLW
H08605	1961	20,000	Early Alaska Datum	MLLW
H08620	1961	5,000	Early Alaska Datum	MLLW
H08621	1961	10,000	NAD 27 geographic	MLLW
H08622	1961	10,000	Early Alaska Datum	MLLW
H08623	1961	10,000	Early Alaska Datum	MLLW
H08624	1961	10,000	Early Alaska Datum	MLLW
H08640	1962	10,000	Early Alaska Datum	MLLW
H08641	1962	10,000	Early Alaska Datum	MLLW
H08653	1962	10,000	Early Alaska Datum	MLLW
H08654	1962	10,000	Early Alaska Datum	MLLW
H08659	1962	10,000	Early Alaska Datum	MLLW
H08660	1962	10,000	Early Alaska Datum	MLLW
H08665	1962	10,000	Early Alaska Datum	MLLW
H08666	1962	20,000	Early Alaska Datum	MLLW
H08690	1962	10,000	Early Alaska Datum	MLLW
H08691	1962	10,000	Early Alaska Datum	MLLW
H08533	1963	10,000	Early Alaska Datum	MLLW
H08692	1963	10,000	Early Alaska Datum	MLLW
H08715	1963	10,000	Early Alaska Datum	MLLW
H08716	1963	10,000	Early Alaska Datum	MLLW
H08755	1963	10,000	Early Alaska Datum	MLLW
H08756	1963	10,000	Early Alaska Datum	MLLW
H08757	1963	10,000	Early Alaska Datum	MLLW
H08758	1963	10,000	Early Alaska Datum	MLLW
H08759	1963	10,000	Early Alaska Datum	MLLW
H08769	1963	10,000	Early Alaska Datum	MLLW
H08770	1963	10,000	Early Alaska Datum	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
H08771	1963	10,000	Early Alaska Datum	MLLW
H08798	1963	10,000	Early Alaska Datum	MLLW
H08785	1964	10,000	Early Alaska Datum	MLLW
H08799	1964	10,000	NAD 27 geographic	MLLW
H08800	1964	10,000	Early Alaska Datum	MLLW
H08801	1964	10,000	Early Alaska Datum	MLLW
H08802	1964	5,000	Early Alaska Datum	MLLW
H08815	1964	10,000	NAD 27 geographic	MLLW
H08816	1964	20,000/10,000	NAD 27 geographic	MLLW
H08817	1964	20,000	Early Alaska Datum	MLLW
H08688	1965	10,000	Early Alaska Datum	MLLW
H08872	1965	5,000	Early Alaska Datum	MLLW
H09101	1965	10,000	Early Alaska Datum	MLLW
H08906	1966	10,000	Early Alaska Datum	MLLW
H08907	1966	10,000	Early Alaska Datum	MLLW
H09000	1966	10,000	NAD 27 geographic	MLLW
H08945	1967	10,000	Early Alaska Datum	MLLW
H08946	1967	10,000	Early Alaska Datum	MLLW
H08947	1967	10,000	NAD 27 geographic	MLLW
H08948	1967	5,000	Early Alaska Datum	MLLW
H08961	1967	10,000	NAD 27 geographic	MLLW
H08658	1968	5,000	Early Alaska Datum	MLLW
H09039	1968	10,000	Early Alaska Datum	MLLW
H09040	1968	10,000	Early Alaska Datum	MLLW
H09041	1968	10,000	Early Alaska Datum	MLLW
H09055	1968	10,000	Early Alaska Datum	MLLW
H09062	1968	20,000	Early Alaska Datum	MLLW
H09054	1969	10,000	Early Alaska Datum	MLLW
H09056	1969	10,000	Early Alaska Datum	MLLW
H09057	1969	10,000	Early Alaska Datum	MLLW
H09058	1969	10,000	Early Alaska Datum	MLLW
H09066	1969	10,000	Early Alaska Datum	MLLW
H09069	1969	10,000	Early Alaska Datum	MLLW
H09070	1969	10,000	Early Alaska Datum	MLLW
H09078	1969	5,000	Early Alaska Datum	MLLW
H09079	1969	5,000	Early Alaska Datum	MLLW
H09080	1969	5,000	Early Alaska Datum	MLLW
H09081	1969	5,000	Early Alaska Datum	MLLW
H09082	1969	10,000	Early Alaska Datum	MLLW
H09083	1969	10,000	Early Alaska Datum	MLLW
H09084	1969	10,000	Early Alaska Datum	MLLW
H09085	1969	10,000	Early Alaska Datum	MLLW
H09091	1969	20,000	Early Alaska Datum	MLLW
H09092	1969	20,000	NAD 27 geographic	MLLW
H08960	1970	10,000	Early Alaska Datum	MLLW
H09121	1970	20,000	Early Alaska Datum	MLLW

Survey ID	*Year*	*Scale or Resolution*	*Original Horizontal Datum*	*Original Vertical Datum*
H09122	1970	20,000	Early Alaska Datum	MLLW
H09123	1970	10,000	Early Alaska Datum	MLLW
H09124	1970	10,000	Early Alaska Datum	MLLW
H09125	1970	10,000	Early Alaska Datum	MLLW
H09126	1970	10,000	Early Alaska Datum	MLLW
H09127	1970	10,000	Early Alaska Datum	MLLW
H09128	1970	10,000	NAD 27 geographic	MLLW
H09138	1970	20,000	Early Alaska Datum	MLLW
H09139	1970	20,000	Early Alaska Datum	MLLW
H09140	1970	20,000	Early Alaska Datum	MLLW
H09141	1970	20,000	Early Alaska Datum	MLLW
H09142	1970	10,000	NAD 27 geographic	MLLW
H09143	1970	10,000	Early Alaska Datum	MLLW
H09157	1970	10,000	Early Alaska Datum	MLLW
H09158	1970	10,000	Early Alaska Datum	MLLW
H09159	1970	10,000	Early Alaska Datum	MLLW
H09160	1970	10,000	Early Alaska Datum	MLLW
H09161	1970	5,000	Early Alaska Datum	MLLW
H09182	1970	10,000	Early Alaska Datum	MLLW
H09184	1970	10,000	Early Alaska Datum	MLLW
H09214	1970	10,000	Early Alaska Datum	MLLW
H09330	1970	20,000	NAD 27 geographic	MLLW
H09191	1971	10,000	NAD 27 geographic	MLLW
H09192	1971	10,000	NAD 27 geographic	MLLW
H09193	1971	1:5,000	NAD 27 geographic	MLLW
H09194	1971	20,000	NAD 27 geographic	MLLW
H09213	1971	10,000	NAD 27 geographic	MLLW
H09215	1971	10,000	Early Alaska Datum	MLLW
H09216	1971	10,000	Early Alaska Datum	MLLW
H09217	1971	10,000	Early Alaska Datum	MLLW
H09218	1971	10,000	Early Alaska Datum	MLLW
H09219	1971	10,000	Early Alaska Datum	MLLW
H09220	1971	10,000	Early Alaska Datum	MLLW
H09221	1971	10,000	Early Alaska Datum	MLLW
H09222	1971	5,000	Early Alaska Datum	MLLW
H09223	1971	20,000	Early Alaska Datum	MLLW
H09268	1971	10,000	Early Alaska Datum	MLLW
H09146	1972	10,000	Early Alaska Datum	MLLW
H09269	1972	10,000	NAD 27 geographic	MLLW
H09285	1972	10,000	Early Alaska Datum	MLLW
H09286	1972	10,000	NAD 27 geographic	MLLW
H09287	1972	10,000	NAD 27 geographic	MLLW
H09288	1972	10,000	NAD 27 geographic	MLLW
H09309	1972	10,000	Early Alaska Datum	MLLW
H09315	1972	20,000	Early Alaska Datum	MLLW
H09316	1972	20,000	Early Alaska Datum	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
H09317	1972	20,000	Early Alaska Datum	MLLW
H09318	1972	20,000	Early Alaska Datum	MLLW
H09331	1972	10,000	Early Alaska Datum	MLLW
H09332	1972	10,000	NAD 27 geographic	MLLW
H09333	1972	10,000	NAD 27 geographic	MLLW
H09343	1972	10,000	NAD 27 geographic	MLLW
H09370	1973	10,000	Early Alaska Datum	MLLW
H09392	1973	10,000	Early Alaska Datum	MLLW
H09393	1973	10,000	Early Alaska Datum	MLLW
H09394	1973	20,000	Early Alaska Datum	MLLW
H09401	1973	10,000	Early Alaska Datum	MLLW
H09402	1973	10,000	NAD 27 geographic	MLLW
H09403	1973	10,000	NAD 27 geographic	MLLW
H09405	1973	20,000	Early Alaska Datum	MLLW
H09407	1973	10,000	NAD 27 geographic	MLLW
H09480	1974	20,000	Early Alaska Datum	MLLW
H09481	1974	20,000	Early Alaska Datum	MLLW
H09482	1974	20,000	Early Alaska Datum	MLLW
H09483	1974	10,000	Early Alaska Datum	MLLW
H09571	1975	10,000	Early Alaska Datum	MLLW
H09572	1975	10,000	Early Alaska Datum	MLLW
H09638	1976	5,000	Early Alaska Datum	MLLW
H09650	1976	10,000	Early Alaska Datum	MLLW
H09651	1976	10,000	Early Alaska Datum	MLLW
H09652	1976	10,000	Early Alaska Datum	MLLW
H09653	1976	10,000	Early Alaska Datum	MLLW
H09729	1977	10,000	Early Alaska Datum	MLLW
H09754	1978	5,000	Early Alaska Datum	MLLW
H09756	1978	5,000	Early Alaska Datum	MLLW
H09757	1978	10,000	Early Alaska Datum	MLLW
H09791	1978	5,000	Early Alaska Datum	MLLW
H09792	1978	10,000	Early Alaska Datum	MLLW
H09795	1978	10,000	Early Alaska Datum	MLLW
H09817	1979	5,000	Early Alaska Datum	MLLW
H09818	1979	5,000	Early Alaska Datum	MLLW
H09824	1979	10,000	Early Alaska Datum	MLLW
H09825	1979	10,000	Early Alaska Datum	MLLW
H09847	1979	20,000	Early Alaska Datum	MLLW
H09848	1979	20,000	Early Alaska Datum	MLLW
F00228	1980	5,000	NAD 27 geographic	MLLW
H09870	1980	20,000	Early Alaska Datum	MLLW
H09939	1981	20,000	NAD 27 geographic	MLLW
H09976	1981	10,000	NAD 27 geographic	MLLW
H09977	1981	10,000	NAD 27 geographic	MLLW
H09982	1981	20,000	Early Alaska Datum	MLLW
H09987	1981	10,000	NAD 27 geographic	MLLW

Survey ID	*Year*	*Scale or Resolution*	*Original Horizontal Datum*	*Original Vertical Datum*
H09990	1981	10,000	Early Alaska Datum	MLLW
F00240	1982	10,000	Early Alaska Datum	MLLW
H10010	1982	10,000	NAD 27 geographic	MLLW
H10013	1982	10,000	Early Alaska Datum	MLLW
H10047	1982	10,000	Early Alaska Datum	MLLW
H10048	1982	10,000	Early Alaska Datum	MLLW
H10050	1982	10,000	Early Alaska Datum	MLLW
H10051	1982	10,000	Early Alaska Datum	MLLW
H10055	1982	10,000	NAD 27 geographic	MLLW
H10057	1982	10,000	Early Alaska Datum	MLLW
H10060	1982	10,000	Early Alaska Datum	MLLW
H10063	1982	10,000	Early Alaska Datum	MLLW
H10064	1982	10,000	Early Alaska Datum	MLLW
H10065	1982	10,000	NAD 27 geographic	MLLW
F00250	1983	5,000	Early Alaska Datum	MLLW
F00251	1983	5,000	Early Alaska Datum	MLLW
H10085	1983	10,000	NAD 27 geographic	MLLW
H10087	1983	10,000	Early Alaska Datum	MLLW
H10115	1983	20,000	Early Alaska Datum	MLLW
H10118	1983	20,000	Early Alaska Datum	MLLW
H10121	1983	10,000	Early Alaska Datum	MLLW
F00263	1984	10,000	Early Alaska Datum	MLLW
H10133	1984	20,000	Early Alaska Datum	MLLW
H10154	1984	10,000	Early Alaska Datum	MLLW
H10155	1984	10,000	Early Alaska Datum	MLLW
H10159	1984	10,000	Early Alaska Datum	MLLW
H10160	1984	10,000	Early Alaska Datum	MLLW
H10163	1984	10,000	NAD 27 geographic	MLLW
H10174	1985	20,000	NAD 27 geographic	MLLW
H10175	1985	20,000	NAD 27 geographic	MLLW
H10176	1985	10,000	NAD 27 geographic	MLLW
H10201	1985	10,000	NAD 27 geographic	MLLW
H10202	1985	10,000	NAD 27 geographic	MLLW
H10203	1985	10,000	NAD 27 geographic	MLLW
H10204	1985	10,000	NAD 27 geographic	MLLW
H10229	1985	10,000	NAD 27 geographic	MLLW
H10227	1986	20,000	NAD 27 geographic	MLLW
H10228	1986	10,000	NAD 27 geographic	MLLW
H10230	1986	10,000	NAD 27 geographic	MLLW
H10231	1986	20,000	NAD 27 geographic	MLLW
H10233	1986	5,000	NAD 27 geographic	MLLW
H10238	1987	10,000	NAD 27 geographic	MLLW
H10239	1987	10,000	NAD 27 geographic	MLLW
H10240	1987	10,000	NAD 27 geographic	MLLW
H10256	1987	40,000	NAD 27 geographic	MLLW
H10257	1987	10,000	NAD 27 geographic	MLLW

Survey ID	*Year*	*Scale or Resolution*	*Original Horizontal Datum*	*Original Vertical Datum*
H10258	1987	10,000	NAD 27 geographic	MLLW
H10265	1988	20,000	NAD 27 geographic	MLLW
H10268	1988	10,000	NAD 83 geographic	MLLW
H10269	1988	20,000	NAD 27 geographic	MLLW
H10271	1988	10,000	NAD 83 geographic	MLLW
H10272	1988	20,000	NAD 27 geographic	MLLW
H10288	1988	20,000	NAD 27 geographic	MLLW
H10289	1988	20,000	NAD 27 geographic	MLLW
F00339	1989	10,000	Early Alaska Datum	MLLW
H10295	1989	10,000	NAD 27 geographic	MLLW
H10296	1989	20,000	NAD 27 geographic	MLLW
H10297	1989	20,000	NAD 27 geographic	MLLW
H10316	1989	5,000	NAD 27 geographic	MLLW
H10318	1989	10,000	NAD 83 geographic	MLLW
H10319	1989	20,000	NAD 83 geographic	MLLW
F00358	1990	5,000	NAD 83 geographic	MLLW
H10333	1990	10,000	NAD 83 geographic	MLLW
H10334	1990	20,000	NAD 83 geographic	MLLW
H10335	1990	10,000	NAD 83 geographic	MLLW
H10336	1990	10,000	NAD 83 geographic	MLLW
H10338	1990	10,000	NAD 83 geographic	MLLW
H10357	1990	10,000	NAD 83 geographic	MLLW
H10358	1990	10,000	NAD 83 geographic	MLLW
H10370	1991	5,000	NAD 83 geographic	MLLW
H10371	1991	10,000	NAD 83 geographic	MLLW
H10374	1991	20,000	NAD 83 geographic	MLLW
H10376	1991	10,000	NAD 83 geographic	MLLW
H10377	1991	10,000	NAD 83 geographic	MLLW
H10407	1991	10,000	NAD 83 geographic	MLLW
H10408	1991	10,000	NAD 83 geographic	MLLW
H10419	1992	10,000	NAD 83 geographic	MLLW
H10420	1992	10,000	NAD 83 geographic	MLLW
H10425	1992	10,000	NAD 83 geographic	MLLW
H10426	1992	10,000	NAD 83 geographic	MLLW
H10459	1993	10,000	NAD 83 geographic	MLLW
H10462	1993	10,000	NAD 83 geographic	MLLW
H10463	1993	10,000	NAD 83 geographic	MLLW
H10465	1993	10,000	NAD 83 geographic	MLLW
H10466	1993	10,000	NAD 83 geographic	MLLW
H10467	1993	10,000	NAD 83 geographic	MLLW
H10468	1993	10,000	NAD 83 geographic	MLLW
H10469	1993	10,000	NAD 83 geographic	MLLW
H10470	1993	10,000	NAD 83 geographic	MLLW
F00416	1995	5,000	NAD 83 geographic	MLLW
H10592	1995	10,000	NAD 83 geographic	MLLW
H10593AB	1995	20,000	NAD 83 geographic	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
H10594	1995	10,000	NAD 83 geographic	MLLW
H10595	1995	10,000	NAD 83 geographic	MLLW
H10596	1995	10,000	NAD 83 geographic	MLLW
H10601AB	1995	20,000	NAD 83 geographic	MLLW
H10602	1995	10,000	NAD 83 geographic	MLLW
H10604	1995	10,000	NAD 83 geographic	MLLW
H10607	1995	10,000	NAD 83 geographic	MLLW
F00425	1996	10,000	NAD 83 geographic	MLLW
H10672	1996	10,000	NAD 83 geographic	MLLW
H10673	1996	10,000	NAD 83 geographic	MLLW
H10676	1996	10,000	NAD 83 geographic	MLLW
H10677	1996	40,000	NAD 83 geographic	MLLW
H10678	1996	10,000	NAD 83 geographic	MLLW
H10679	1996	10,000	NAD 83 geographic	MLLW
H10680	1996	10,000	NAD 83 geographic	MLLW
H10681	1996	10,000	NAD 83 geographic	MLLW
H10682	1996	10,000	NAD 83 geographic	MLLW
H10732	1996	10,000	NAD 83 geographic	MLLW
H10734A	1996	10,000	NAD 83 geographic	MLLW
F00432	1997	10,000	NAD 83 geographic	MLLW
H10733	1997	10,000	NAD 83 geographic	MLLW
H10734B	1997	10,000	NAD 83 geographic	MLLW
H10735	1997	10,000	NAD 83 geographic	MLLW
H10737	1997	10,000	NAD 83 geographic	MLLW
H10738	1997	10,000	NAD 83 geographic	MLLW
H10739	1997	10,000	NAD 83 geographic	MLLW
H10740	1997	10,000	NAD 83 geographic	MLLW
H10742	1997	20,000	NAD 83 geographic	MLLW
H10743	1997	40,000	NAD 83 geographic	MLLW
H10746	1997	5,000	NAD 83 geographic	MLLW
H10751	1997	10,000	NAD 83 geographic	MLLW
H10753	1997	20,000	NAD 83 geographic	MLLW
H10754	1997	40,000	NAD 83 geographic	MLLW
H10756	1997	10,000	NAD 83 geographic	MLLW
H10758	1997	10,000	NAD 83 geographic	MLLW
H10862	1997	10,000	NAD 83 geographic	MLLW
H10736	1998	10,000	NAD 83 geographic	MLLW
H10806	1998	10,000	NAD 83 geographic	MLLW
H10807	1998	10,000	NAD 83 geographic	MLLW
H10808	1998	10,000	NAD 83 geographic	MLLW
H10810	1998	10,000	NAD 83 geographic	MLLW
H10811	1998	10,000	NAD 83 geographic	MLLW
H10812	1998	10,000	NAD 83 geographic	MLLW
H10815	1998	10,000	NAD 83 geographic	MLLW
H10816	1998	10,000	NAD 83 geographic	MLLW
H10818	1998	10,000	NAD 83 geographic	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
F00451	1999	10,000	NAD 83 geographic	MLLW
H10860	1999	10,000	NAD 83 geographic	MLLW
H10861	1999	10,000	NAD 83 geographic	MLLW
H10864	1999	20,000	NAD 83 geographic	MLLW
H10865	1999	10,000	NAD 83 geographic	MLLW
H10866	1999	10,000	NAD 83 geographic	MLLW
H10869	1999	10,000	NAD 83 geographic	MLLW
H10870	1999	10,000	NAD 83 geographic	MLLW
H10879	1999	10,000	NAD 83 geographic	MLLW
H10880	1999	20,000	NAD 83 geographic	MLLW
H10881	1999	20,000	NAD 83 geographic	MLLW
H10882	1999	20,000	NAD 83 geographic	MLLW
H10883	1999	10,000	NAD 83 geographic	MLLW
H10944	1999	10,000	NAD 83 geographic	MLLW
H10949	2000	20,000	NAD 83 geographic	MLLW
H10950	2000	20,000	NAD 83 geographic	MLLW
H10959	2000	20,000	NAD 83 geographic	MLLW
H10967 +	2000	5 m	UTM Zone 9 NAD 83	MLLW
H10972	2000	2,000	NAD 83 geographic	MLLW
H10987 +	2000	5 m	UTM Zone 9 NAD 83	MLLW
H10988 +	2000	5 m	UTM Zone 9 NAD 83	MLLW
H11009 +	2000	5 m	UTM Zone 9 NAD 83	MLLW
H10951	2001	20,000	NAD 83 geographic	MLLW
H11048	2001	10,000	NAD 83 geographic	MLLW
H11049	2001	10,000	NAD 83 geographic	MLLW
H11050 +	2001	5 m	UTM Zone 8 NAD 83	MLLW
H11051	2001	10,000	NAD 83 geographic	MLLW
H11052	2001	10,000	NAD 83 geographic	MLLW
H11053	2001	10,000	NAD 83 geographic	MLLW
H11058	2001	10,000	NAD 83 geographic	MLLW
H11097	2002	10,000	NAD 83 geographic	MLLW
H11098	2002	10,000	NAD 83 geographic	MLLW
H11099	2002	10,000	NAD 83 geographic	MLLW
H11105	2002	10,000	NAD 83 geographic	MLLW
H11106	2002	10,000	NAD 83 geographic	MLLW
H11107 +	2002	5 m	NAD 83 geographic	MLLW
H11108	2002	10,000	NAD 83 geographic	MLLW
H11109	2002	10,000	NAD 83 geographic	MLLW
H11110	2002	10,000	NAD 83 geographic	MLLW
H11111	2002	10,000	NAD 83 geographic	MLLW
H11121	2002	5,000	NAD 83 geographic	MLLW
H11131	2002	10,000	NAD 83 geographic	MLLW
H11160	2002	10,000	NAD 83 geographic	MLLW
H11161	2002	10,000	NAD 83 geographic	MLLW
H11162	2002	10,000	NAD 83 geographic	MLLW
H11163	2002	10,000	NAD 83 geographic	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
H11164	2002	20,000	NAD 83 geographic	MLLW
H11165	2002	10,000	NAD 83 geographic	MLLW
H11112	2003	10,000	NAD 83 geographic	MLLW
H11113	2003	10,000	NAD 83 geographic	MLLW
H11117	2003	10,000	NAD 83 geographic	MLLW
H11118	2003	10,000	NAD 83 geographic	MLLW
H11120	2003	10,000	NAD 83 geographic	MLLW
H11134	2003	20,000	NAD 83 geographic	MLLW
H11236	2003	10,000	NAD 83 geographic	MLLW
H11237	2003	10,000	NAD 83 geographic	MLLW
H11238	2003	10,000	NAD 83 geographic	MLLW
H11239	2003	10,000	NAD 83 geographic	MLLW
H11240	2003	10,000	NAD 83 geographic	MLLW
F00497	2004	5,000	NAD 83 geographic	MLLW
H11114	2004	10,000	NAD 83 geographic	MLLW
H11115	2004	10,000	NAD 83 geographic	MLLW
H11116	2004	10,000	NAD 83 geographic	MLLW
H11119	2004	10,000	NAD 83 geographic	MLLW
H11123 #	2004	5 m	UTM Zone 8 NAD 83	MLLW
H11124 #	2004	Various	UTM Zone 8 NAD 83	MLLW
H11130 +	2004	5 m	NAD 83 geographic	MLLW
H11334 #	2004	Various	UTM Zone 9 NAD 83	MLLW
H11335 #	2004	Various	UTM Zone 9 NAD 83	MLLW
H11354	2004	10,000	NAD 83 geographic	MLLW
H11358 #	2004	10 m	UTM Zone 8 NAD 83	MLLW
H11362 #	2004	Various	UTM Zone 8 NAD 83	MLLW
H11369 +	2004	10 m	NAD 83 geographic	MLLW
F00503 #	2005	5 m	UTM Zone 8 NAD 83	MLLW
H11122 #	2005	10 m	UTM Zone 8 NAD 83	MLLW
H11135 #	2005	10 m	UTM Zone 8 NAD 83	MLLW
H11270 #	2005	10 m	UTM Zone 8 NAD 83	MLLW
H11271 +	2005	10 m	NAD 83 geographic	MLLW
H11272 #	2005	10 m	UTM Zone 8 NAD 83	MLLW
H11363 #	2005	Various	UTM Zone 8 NAD 83	MLLW
H11364 #	2005	Various	UTM Zone 8 NAD 83	MLLW
H11403 #	2005	20 m	UTM Zone 8 NAD 83	MLLW
H11404 #	2005	10 m	UTM Zone 8 NAD 83	MLLW
H11405 #	2005	12 m	UTM Zone 8 NAD 83	MLLW
H11406 #	2005	12 m	UTM Zone 9 NAD 83	MLLW
H11427 #	2005	Various	UTM Zone 8 NAD 83	MLLW
H11428 #	2005	5 m	UTM Zone 8 NAD 83	MLLW
H11449 #	2005	Various	UTM Zone 8 NAD 83	MLLW
H11469 #	2005	Various	UTM Zone 8 NAD 83	MLLW
H11470 #	2005	Various	UTM Zone 8 NAD 83	MLLW
H11507 #	2005	22 m	UTM Zone 9 NAD 83	MLLW
H11508 #	2005	Various	UTM Zone 9 NAD 83	MLLW

Survey ID	*Year*	*Scale or Resolution*	*Original Horizontal Datum*	*Original Vertical Datum*
H11509 #	2005	12m	UTM Zone 9 NAD 83	MLLW
H11127 #	2006	Various	UTM Zone 8 NAD 83	MLLW
H11128 #	2006	10m	UTM Zone 8 NAD 83	MLLW
H11447 #	2006	Various	UTM Zone 8 NAD 83	MLLW
H11448 #	2006	Various	UTM Zone 8 NAD 83	MLLW
H11538 #	2006	3m	UTM Zone 8 NAD 83	MLLW
H11539 #	2006	3m	UTM Zone 8 NAD 83	MLLW
H11540 #	2006	3m	UTM Zone 8 NAD 83	MLLW
H11577 #	2006	20m	UTM Zone 8 NAD 83	MLLW
H11578 #	2006	5m	UTM Zone 8 NAD 83	MLLW
H11579 #	2006	2m	UTM Zone 8 NAD 83	MLLW
H11569 #	2007	15m	UTM Zone 8 NAD 83	MLLW
H11570 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11571 #	2007	Various	UTM Zone 8 NAD 83	MLLW
H11572 #	2007	10m	UTM Zone 9 NAD 83	MLLW
H11573 #	2007	20m	UTM Zone 8 NAD 83	MLLW
H11574 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11586 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11659 #	2007	3m	UTM Zone 8 NAD 83	MLLW
H11660 #	2007	3m	UTM Zone 8 NAD 83	MLLW
H11661 #	2007	3m	UTM Zone 8 NAD 83	MLLW
H11662 #	2007	3m	UTM Zone 8 NAD 83	MLLW
H11663 #	2007	3m	UTM Zone 8 NAD 83	MLLW
H11677 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11678 #	2007	5m	UTM Zone 8 NAD 83	MLLW
H11679 #	2007	Various	UTM Zone 8 NAD 83	MLLW
H11688 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11690 #	2007	5m	UTM Zone 8 NAD 83	MLLW
H11691 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11692 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11696 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11697 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11698 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11699 #	2007	15m	UTM Zone 8 NAD 83	MLLW
H11700 #	2007	5m	UTM Zone 8 NAD 83	MLLW
H11701 #	2007	5m	UTM Zone 8 NAD 83	MLLW
H11702 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11703 #	2007	5m	UTM Zone 8 NAD 83	MLLW
H11704 #	2007	15m	UTM Zone 8 NAD 83	MLLW
H11705 #	2007	10m	UTM Zone 8 NAD 83	MLLW
H11706 #	2007	15m	UTM Zone 8 NAD 83	MLLW
H11707 #	2007	15m	UTM Zone 8 NAD 83	MLLW
H11708 #	2007	15m	UTM Zone 8 NAD 83	MLLW
H11727 #	2007	3m	UTM Zone 8 NAD 83	MLLW
H11759 #	2007	20m	UTM Zone 8 NAD 83	MLLW
H11760 #	2007	10m	UTM Zone 8 NAD 83	MLLW

Survey ID	***Year***	***Scale or Resolution***	***Original Horizontal Datum***	***Original Vertical Datum***
H11844 #	2008	8 m	UTM Zone 8 NAD 83	MLLW
H11845 #	2008	8 m	UTM Zone 8 NAD 83	MLLW
H11846 #	2008	4 m	UTM Zone 8 NAD 83	MLLW
H11849 #	2008	4 m	UTM Zone 8 NAD 83	MLLW
H11850 #	2008	4 m	UTM Zone 8 NAD 83	MLLW
H11865 #	2008	3 m	UTM Zone 8 NAD 83	MLLW
H11917 #	2008	16 m	UTM Zone 8 NAD 83	MLLW
H11993 #	2008	2 m	UTM Zone 8 NAD 83	MLLW
H11998 #	2008	16 m	UTM Zone 8 NAD 83	MLLW
D00143 #	2009	4 m	UTM Zone 8 NAD 83	MLLW
D00144 #	2009	4 m	UTM Zone 8 NAD 83	MLLW
D00145 #	2009	4 m	UTM Zone 8 NAD 83	MLLW
D00146 #	2009	4 m	UTM Zone 8 NAD 83	MLLW
H11126 #	2009	5 m	UTM Zone 8 NAD 83	MLLW

# denotes surveys available in bathymetric attributed grid (BAG) format
+ denotes surveys available in ASCII grid format

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